EAST AFRICA HIGH COMMISSION

EAST AFRICAN AGRICULTURE AND FORESTRY RESEARCH ORGANISATION

(Incorporating the East African Agricultural Research Institute, Amani)

ANNUAL REPORT 1952

Postal Address: P.O. Box 21, Kikuyu, Kenya

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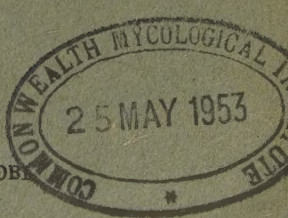

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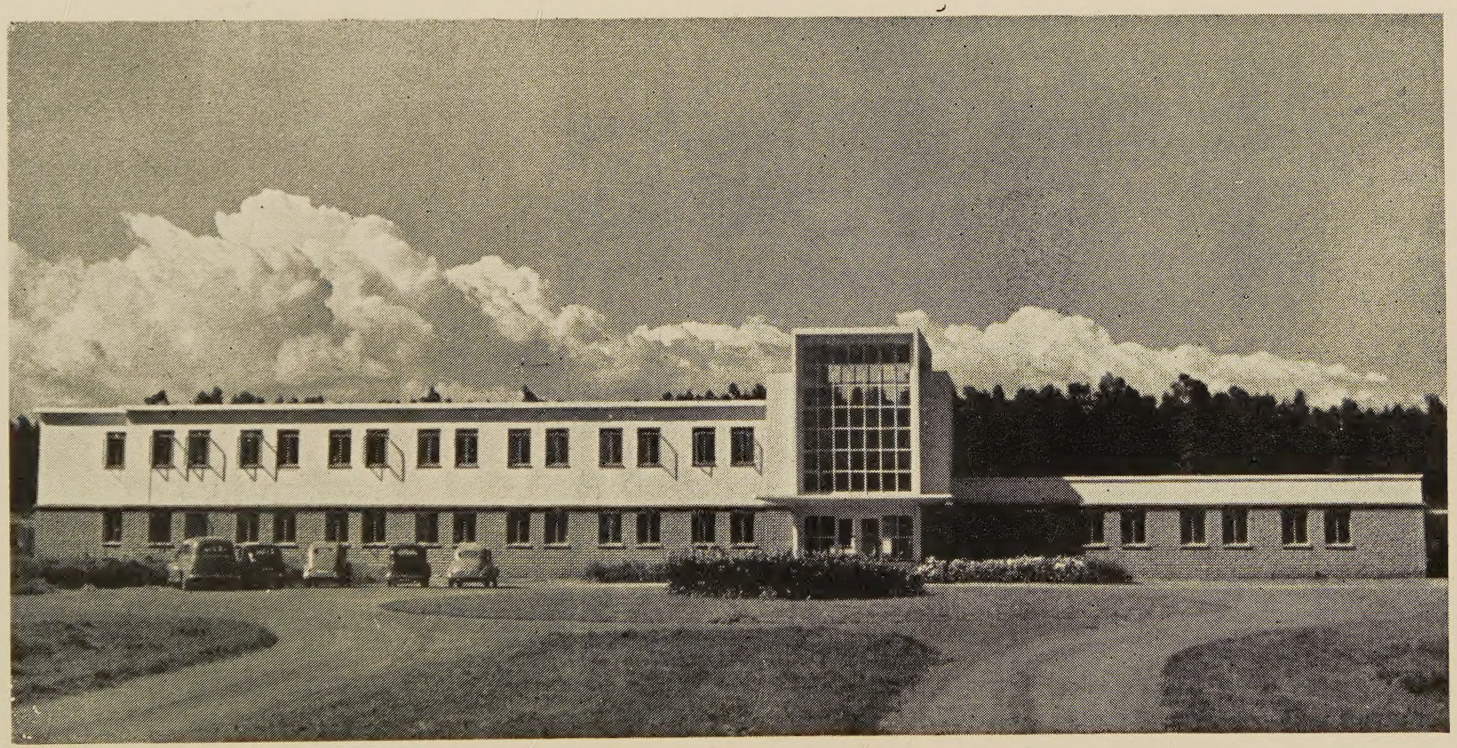

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THE COMBINED HEADQUARTERS OF E.A.A.F.R.O. AND E.A.V.R.O. AT MUGUGA, KENYA COLONY

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CONTENTS

	Page
Staff List	1
Report by Director	5
Complete List of Publications, 1948-1952	17
Rainfall Statistics	23
Library	24
E.A. Agricultural Journal	25
Report by Dr. Hursh on Forest Management in Relation to Climate, Water and Soil Resources	26
Sectional Reports:	
Plant Pathology	35
Plant Breeding and Genetics	42
Crop Insecticides	46
Plant Physiology	48
Clove Research Scheme	54
Forestry	55
Forest Entomology	58
Systematic Botany	61
Soil Microbiology	68
Soil Chemistry	69
Soil Physics	78
Soil Survey	80
Statistics	85
Animal Industry	86
Attached Colonial Development and Welfare Schemes:	
Termite Research	91
Ecological Training	93
Reports by Officers of Overseas Food Corporation	94

Staff List for the Year 1952

(Including Officers of the Clove Research Scheme, the Climatic Data, Termites, and Ecology Schemes)

DIRECTOR

Sir Bernard A. Keen, D.Sc., F.Inst.P., F.R.S.

DEPUTY DIRECTOR

H. H. Storey, C.M.G., M.A., Ph.D., F.R.S.

HEAD OF JOINT ANIMAL INDUSTRY DIVISION

M. H. French, O.B.E., M.A., Ph.D., Dip. Agric.

RESEARCH OFFICERS

H. F. Birch, Ph.D.	*Soil Chemistry*
G. T. Chamberlain	*Spectrochemistry*
L. R. Doughty, B.Sc. (Agric.), N.D.A.	*Plant Breeding and Genetics*
D. W. Duthie, M.A., Ph.D., F.R.I.C.	*Biochemistry* *Editor, E.A. Agricultural Journal*
M. T. Friend, M.Sc., A.R.I.C.	*General Analysis*
J. C. M. Gardner, C.I.E., A.R.C.S., D.I.C., Dip. For.	*Forest Entomology*
J. Glover, M.Sc., M.I. Biol.	*Plant Physiology*
P. J. Greenway, O.B.E., F.L.S.	*Systematic Botany*
A. L. Griffith, O.B.E., M.A., D.Sc.	*Forestry*
P. R. Hesse, B.Sc., A.R.I.C.	*Soil Chemistry*
D. L. Jennings, B.Sc.	*Plant Breeding*
G. H. Gethin Jones, M.Sc.	*Soil Survey*
D. Rudd Jones, M.A., Ph.D., M.I. Biol.	*Plant Pathology*
K. S. McKinlay, B.Sc.	*Entomology*
Miss J. Meiklejohn, D.Sc. *(Seconded from Rothamsted Experimental Station, England)*	*Soil Microbiology*

F. J. Nutman, O.B.E., D.Sc., D.I.C. (*Seconded as Director, Clove Research Scheme, Zanzibar*)	*Plant Physiology*
H. C. Pereira, Ph.D.	*Soil Physics*
P. Robinson, B.A., Dip. Stat.	*Statistics*
R. M. Scott, B.Sc.	*Soil Survey*
Miss F. M. L. Sheffield, D.Sc.	*Cytology*
B. E. St. L. Stuart, B.A.	*Forestry*
B. Verdcourt, B.Sc., F.L.S.	*Systematic Botany*

Scientific Assistants

Mrs. M. A. Ledger (*to September,* 1952)	*Animal Industry*
Miss M. Maclean, B.Sc.	*Spectrochemistry*
W. B. May, F.R.H.S.	*Horticulture*
Mrs. I. B. Pereira (*from September,* 1952)	*Animal Industry*
Mrs. A. K. Ryland, B.Sc.	*Plant Pathology*
Mrs. B. Scott	*Forest Entomology*
Count A. E. Starzenski	*Systematic Botany*

Field and Farm Staff

D. G. Gourlay, B.A. (Agric.)	*Field Experimentalist*
H. P. Ledger, N.D.D.	*Farm Manager*
T. Graham	*Field Assistant*
P. H. Hosegood	*Field Assistant*
T. F. C. Robins (*Seconded to Clove Research Scheme, Zanzibar*)	*Field Assistant*

Administrative Staff

Miss B. Adam	*Registry Clerk*
Mrs. W. Griffith	*Clerical Assistant*

L. C. Martin, M.B.E.	*Maintenance Superintendent*
T. Matthews, T.D. (*on retirement leave*)	*Secretary*
Miss J. Nutman	*Assistant to Editor E.A. Agricultural Journal*
Miss J. Ossent, M.A. (*on retirement leave*)	*Research Librarian*
Mrs. M. F. Skipper	*Clerical Assistant*
Miss M. A. E. Vardy	*Private Secretary to Director*
Mrs. L. Verdcourt, A.L.A.	*Acting Librarian*
S. G. Walter	*Acting Secretary*
A. F. S. Warwick	*Storekeeper*
Mrs. I. M. Warwick	*Stenographer*

UNDER COLONIAL DEVELOPMENT AND WELFARE SCHEMES CONNECTED WITH THE ORGANISATION

W. V. Harris, M.Sc., A.I.C.T.A., M.I. Biol.	*Termite Research*
Miss P. B. Kemp, M.A.	,, ,,
W. A. Sands, B.Sc., A.R.C.S., D.I.C.	,, ,,

C. G. Trapnell, O.B.E., B.A.	*Ecological Training*
N. R. Brockington, B.Sc.	,, ,,
I. Langdale Brown, B.Sc.	,, ,,
E. C. Trump, B.Sc.	,, ,,

V. F. Eastop, B.Sc. (*Colonial Research Fellow*)	*Entomology*

A. Walter, O.B.E.	*Agricultural Meteorology*

Miss F. M. Roberts, Ph.D. — *Clove Research*
(*Seconded from Rothamsted Experimental Station, England*)

M. J. Way, B. A. — *Clove Research*
(*to July, 1952*)
(*Seconded from Rothamsted Experimental Station, England*)

UNDER THE FULBRIGHT AGREEMENT, U.S.A.

C. R. Hursh, Ph.D. — *Forest Hydrology*
(*Chief, Division of Watershed Management and Forest Influences, Southeastern Forest Experiment Station, United States Forest Service*)

REPORT BY THE DIRECTOR

(I) Introduction

The year 1952, the first full year at the Muguga Headquarters, disclosed, as would be expected, a number of points where adjustments and improvements were needed. These items ranged over construction, administrative and financial procedures, scientific organisation, and co-operation with the territories. None of these was serious; those capable of local adjustment are being remedied; others, needing action from outside E.A.A.F.R.O. have been brought to the notice of those concerned.

But, although 1952 was our first full year, it was not a normal one owing to the consequences of the declaration by the Kenya Government of a State of Emergency in October. The direct and indirect interruptions to our programme might have been serious. The greater proportion of our male staff joined the Kenya Police Reserve, while the remainder joined the Special Police; several of the women staff are giving useful assistance in office and telephone duties. The routine and short-notice night patrols and other duties constitute a handicap to the day-time research work, and further inconveniences have been caused by the necessity to postpone some journeys to, and work at, outside centres, because of the pressure of local duties. It is a tribute to the determination and enthusiasm of the E.A.A.F.R.O. scientific and administrative staff that the adverse effects on our work have been held at their present low level.

In spite of this slowing-up, the experience of 1952 was sufficient to show that our general programme and the means of putting it into effect are both sound; major changes will be needed in the future (it has been well said that a programme that did not require alteration was not worth the making) but for some time ahead we expect to be fully occupied in developing the existing programme. This long-range programme was fully discussed in last year's Report, and most of the individual researches in the Sections were also discussed against that general background.

Therefore it is not proposed to repeat that examination in the present Report. It would involve considerable repetition for most researches, because the progress in twelve months does not usually change a research beyond recognition. Instead, some of the items that were of special interest in 1952 will be discussed.

Construction.—All building work during the year has been done by the Maintenance Superintendent, who made considerable savings in costs by using direct labour. The buildings for the joint Animal Industry Division are practically complete, and most are already in use. African quarters for the use of C.D. & W. Schemes attached to E.A.A.F.R.O. were completed, and a start was made on the laboratories and housing for the Plant Quarantine Station, with funds provided by the three territories.

During the year approval was given to a C.D. & W. Scheme to defray further expenditure to December, 1955, which is the closing date of the original ten-year programme. The capital needs in this new scheme are small, and are mostly made up of extra senior and junior African houses, a dispensary, and improvements to roads and drainage systems.

Experience has shown that maintenance costs for all our buildings will exceed expectations, owing to the deeply fissured nature of the area. These cracks are bridged over at the surface by the holding action of plant roots on the loose top soil, and only become obvious after heavy rain on cleared areas has washed the soil down into the deeper part of the cracks. This hazard could hardly have been foreseen, and the existence of this extensive ramifying system of cracks was unsuspected by our Consultants, the East African Railways and Harbours. Fortunately, the administration block, the laboratories and the library were built with flat reinforced concrete roofs, but other buildings including the houses will be less stable.

Publicity.—Over 400 visitors came to Muguga during the year. About half were organised parties, including government officers on courses. This number may be expected to increase, especially when the animal and arable operations of the Animal Industry Division get into full stride, and when the E.A.V.R.O. staff have all arrived. When the fitting of the Conference Room is completed, it will be possible to invite societies and other suitable bodies to hold meetings here and to combine this with an inspection of Muguga. So far, members of the scientific staff have shared the task of guide-demonstrator to the parties. But if the numbers appreciably increase —and it is hoped they will—the appointment of a guide-demonstrator, to relieve the scientific staff from dealing with visitors other than specialists, may be necessary.

Although the encouragement of visitors to Muguga is perhaps the most effective and lasting form of publicity, there are other useful measures. A Press Conference was arranged by the Colonial Office for the Director during his visit to England, and this led to a number of notices and articles in both the overseas and home press. Members of the staff have published a number of popular articles on their work, and have given lectures, addresses and broadcasts. Invitations to give talks to farmers' associations, senior schools, and the like are welcomed.

(II) Scientific Work of The Organisation

For the reason given in the Introduction no attempt is made this year to pass the whole of the scientific work under review. Instead, a brief discussion is given of new developments or of major changes. The Sectional Reports on pp. 35 to 90, should be consulted by those who wish for general details of the year's work. Some idea of the work done since E.A.A.F.R.O. began is given by the list of publications on pp. 17-22.

(a) *New Sections*

During the year three new Sections were opened as part of the long-term research programme. They were Forest Entomology, Soil Microbiology and Soil Physics, whose Sectional Reports will be found on pp. 58, 68 and 78, respectively. Short accounts follow of the work they are doing in relation to the over-all programme. As foreshadowed on p. 14 of the 1951 Report the operations of the Fertiliser Scheme were closed during 1952, and the Departments of Agriculture took over responsibility. The re-examination of the four years' results of this Scheme and the associated Scheme of the Kenya Department of Agriculture, which was to have been made in 1952 by the Specialist Committee on Fertiliser Responses, was deferred until early in 1953. It was decided to widen this examination to include also the other East African work on crop responses.

Forest Entomology.—This work combines a general survey of forest insects (including those infesting forest products as well as the growing tree) with some special problems of immediate economic importance. The survey work is an obvious necessity because, up to the present, practically nothing has been known about the major types of insects present, their distribution and response to climatic variations, or the conditions in which outbreaks occur.

One of the special problems deals with a Cerambycid beetle, found to be a serious pest in Kenya. Although it is a dead-wood borer, it can excavate extensive galleries and breed in the centre of living stems of conifers, entering through external dead wood associated with pruning scars or damage by animals. The economic importance of this in the extensive exotic plantations of Kenya is that, at present, there is no precise means of telling whether a living tree is attacked. The damage, that may affect no less than 80% of the trees, is only disclosed when they are felled and sawn. Laboratory and field studies are under way to learn more about the bionomics of the problem, because it is practically certain that if pruning were abolished, the attack would be reduced to a tolerable level. Meanwhile, improvements in the technique of pruning and protecting the scars are under study by the Kenya Forest Department.

Soil Microbiology.—The microbiological activities in temperate climate soils have been intensively studied for many years, and the results have been used in the evolution of stable agricultural systems. But practically nothing is known about the microbiology of tropical soils, and this ignorance is reflected in the almost complete absence of scientific knowledge about the rôle of organic matter in systems of tropical agriculture. For example, in tropical rain forests about 100 tons per acre per annum of organic matter reaches the soil, but the high temperature, humidity and water percolation, lead to such intense oxidation and disappearance, that there is no deep surface layer of humus as in the forest litter of temperate climates. The idea that the luxurious vegetative growth denotes a high inexhaustible fertility is an illusion. The margin is narrow and the balance delicate; clearing and cultivation cause a rapid decline in fertility.

This is perhaps the extreme condition. But there is only a difference of degree between it and the far more common and important condition found in lower rainfall areas. It is, unfortunately, just these areas that present the big problem in Africa today. In the quite recent past, the centuries-old practice of shifting cultivation with a wide interval of time between successive cultivations, kept the fertility balance in equilibrium. But, not only was this equilibrium lower than that in the uncultivated tropical rain forest; it has been drastically upset by the rapid decrease in the length of the resting period. The problem of devising a stable agricultural system for this new situation, in which the lengths of the resting and arable breaks have been exchanged, is one that will need every particle of scientific and empirical knowledge. One most important aspect is to follow the fate of the organic matter; in technical terms, the study of the causes and extent of the nitrogen and carbon losses, and of the variation of the carbon/nitrogen ratio. It is here that research into the microbiological population of tropical soils and their behaviour may be expected to open up valuable ideas.

Simultaneously, joint work with the Uganda Department of Agriculture on a practical problem (p. 69) is under way.

Soil Physics.—Although the bulk of the experiments are in collaboration with the territories (p. 78) in connection with the immediate practical soil structure problems of restoration of vegetative cover and the use of leys, the basic aspects of the physics programme rest on our need to know more about the moisture régime in tropical soils.

It is equally as important as the other basic question of the fertility status of tropical soils, to which the microbiological studies just outlined should make an effective contribution. Although for purposes of a research programme fertility and moisture problems can be discussed apart, they are interwoven in practice. The fertility level in shifting cultivation agriculture is as much a matter of moisture supply in the soil as it is of plant nutrients. The basic physical problem is the study under tropical conditions of the well-known hydrological equation:—

Precipitation = Run-off + Evaporation + Transpiration + Percolation + Water held in the soil.

This equation has been intensively studied by soil physicists. The phenomena concerned are very complicated, and involve a good deal of parallel research in pure physics — notably into the indirect measurement of radiation in order to arrive at estimates for evaporation and transpiration, because of the experimental difficulties of any direct measurements of these factors. To date, this research work has been done primarily for temperate climate conditions. Repetition for the very different tropical conditions must now be made. Practical questions of urgent importance await the solution of this research work. The most effective use of irrigation water is one problem. The guess-work of irrigation applications (which admittedly have become improved by accumulated experience) would be replaced by a precisely calculated optimum quantity of water. A more important

problem for East Africa is an accurate measurement of percolation — the quantity of water that replenishes the underground water storage. A close assessment of this figure is one of the most important contributions that the soil physicist can make to the development of East Africa. A number of territorial departments are deeply interested in this information. It is as vital for the correct formulation of government policy on such matters as how much of the underground water table can safely be drawn on for industrial development, as it is for making the decision whether or not to increase the number of tube wells for animal and arable husbandry developments in semi-arid areas, or to replace bamboo by commercially exploitable soft-wood plantations. This last query arose some years ago in Kenya, and gave rise to much controversy around the assertion that the exotic soft woods would use more water than bamboo, and thus reduce the amount of annual recharge of the underground water. The controversy arose entirely because, at the time, there were no measurements to consult and it continued until it was resolved by soil physical measurements that showed that the soft woods intercepted less water.

The work of the Soil Physics Section is as important for forestry as for agriculture because of the vital connection between forest management and water resources. During 1952 this relation was examined by Dr. Hursh. It is discussed immediately below.

(b) *Forest Management and its Responsibilities*

Dr. Hursh spent nearly the whole of the year in East Africa. As mentioned in last year's Report, his visit was made possible by the provision of the Fulbright Act. His purpose was to make a survey of research needs in the fields of forest management as it relates to local climate, soil and water resources. Dr. Hursh is Chief of the Division of Watershed Management and Forest Influences, Southeastern Forest Experiment Station of the United States Forest Service, where he has conducted extensive experiments on a watershed scale on the effects of forest management on local resources. His report is given in full on pp. 26-35 and deserves the closest attention. He has taken, in each of the three territories, some typical problems to illustrate the three main themes of local climate, soil and water resources, and the vital part that forest management must play in each.

The relation of forest management to local climate is illustrated by two Tanganyika examples. The excessive removal of high forest has apparently reduced the mist, regarded by growers as most desirable for tea production in that area. The second example is the grave land deterioration produced by the unplanned and extensive use of the dry forests in the 20″ to 40″ rainfall areas for nomadic grazing and sporadic cultivation with its constant burning. This is doubly unfortunate because these areas, instead of providing important outlets for resettlement schemes are more likely to present rehabilitation problems of their own. The general remedies for both conditions lie in careful felling to leave large blocks of forest adjoining the tea "islands", together with carefully sited windbreaks, left unfelled from forest or planted if no forest now exists.

In the land resource aspect of forest management Dr. Hursh uses a Uganda example — the Karamoja and adjacent grazing areas to which Uganda has already devoted considerable thought. Dr. Hursh believes that the type of land exploitation here resembles that which is thought to have produced the now widespread desert conditions of the Middle East and adjoining Mediterranean countries. The degeneration appears to have reached the stage where no remnants of the original vegetation now remain, so it is no longer possible to specify what kind of restoration would be the natural one to aim at. The suggestion is that close control of the existing forage resources and of grazing livestock should be combined with an attempt to extend the lower boundary of forest still existing in the higher elevations.

The relations of water resources to forest management are illustrated by two Kenya examples. The first is the bamboo-cypress controversy already discussed above in the paragraphs dealing with soil physics. The second is particularly interesting and important in both its technical and administrative aspects. The Shimba Hills provide surface and underground water supplies that are utilised by the heavy and rapidly expanding demands of Mombasa. Dr. Hursh observes that the present management has produced the reverse of what is wanted. On the hills there is now, partially as a result of annual fires, a poor type of grass cover, of little grazing value and inadequate as a cover for water conservation; along the stream courses, bushes and trees are flourishing. This situation needs complete reversal: a minimum of vegetation along the streams and a forest cover on the hills — either a natural forest or commercial forest selectively harvested to regulate the stand density of the trees to the optimum. Dr. Hursh uses this example to make one of his major points that water conservation in conditions such as these can only be effective, and deterioration, possibly disastrous deterioration, can only be prevented, by working to an overall catchment management plan, drawn up by the technologists, and placed in charge of a single agency which has both the full responsibility and authority for its administration.

Dr. Hursh's recommendations for basic research and technological investigations are in accord with the E.A.A.F.R.O. long-term programme. As might be expected he stresses the importance of the soil physics section of the work.

(c) *The Termination of the Clove Research Scheme*

In previous Reports attention has been drawn to the achievements of this Scheme, directed throughout by Dr. Nutman, on secondment from E.A.A.F.R.O. It will be recalled that the cause and control of "die-back" were fully worked out, and no further research on that aspect was necessary; further, as an incidental to the clove research programme, the cause of the hitherto mysterious "gumming" disease of coconuts was found, and the matter brought to a point from which the investigations could be carried on by a separate team appointed for that purpose by the Zanzibar Government (see 1951 Report, pp. 42 to 44). During 1952 the scientific work on "sudden

death" was carefully considered in consultation with the Colonial Office. It was clear that the work on the fungal origin of the disease had reached a critical stage. The basic research had been carried as far forward as the problem permitted. The over-riding need now was for wide-scale technological investigations, which would serve the double purpose of answering the questions thrown up by the basic researches, and of providing the essential information needed to judge whether control measures were practicable, and if so, what they should be. In further discussions between the Zanzibar Government and the Clove Research team, to which E.A.A.F.R.O. and the Colonial Office also contributed, a long-range technological scheme of work was evolved, which will be controlled by the Zanzibar Government; E.A.A.F.R.O. will be available for consultation by the Government at any time. The formulation of the technological scheme permitted the Clove Research Scheme to be terminated some considerable time before the contemplated closing date, thus releasing the research officers — and the unexpended balance of the funds — for other work. When one considers the negative results of the previous investigations on clove diseases, and the baffling and intractable nature of the problems at the time the Clove Research Scheme began its operations, the measure of achievement of Dr. Nutman and his team appear the more striking. Throughout the duration of the Scheme, the Rothamsted Experimental Station, England, has been of great help. Three Rothamsted officers, each one of whom had special qualifications needed at some particular stage of the research, were seconded to the Scheme for long periods.

(III) Co-ordination

Right from the time of the inception of E.A.A.F.R.O. continuous interest has been shown in the means by which collaboration would be effected with other research bodies and territorial departments. Fears were often expressed that there would be insufficient co-ordination of effort, which would result in much wasteful overlapping together with avoidable gaps in the over-all research plans. Proposals from various sources were put forward for meeting this, but they were necessarily founded more on hypothetical possibilities of lack of co-ordination than on actual instances. The completion of the first full year's work at Muguga provides an appropriate opportunity of listing the various kinds of collaboration that have actually been effected.

Firstly, there is the administrative machinery for organising research, dealt with in Section IV (p. 11) of the 1951 Report. The main function of that machinery is not to plan research programmes for the various interests concerned, but to facilitate such executive actions as are necessary for carrying out the various agreed programmes. It is the Specialist Committees that have the more direct concern in the planning of research, through their examination of the progress of their various researches. These examinations, together with the well-known fact that in many cases the next step in a research is clearly shown by the results to-date, ensure that all relevant considerations receive due weight.

The two Colonial Development and Welfare schemes for termite research and ecology training, whose members rank as part of the staff so long as the schemes are administered by E.A.A.F.R.O., provide an excellent example of the co-ordination of programmes that is made possible by attaching such schemes to a central body like E.A.A.F.R.O. So, too, does the year's secondment of Dr. Jane Meiklejohn from the Rothamsted Experimental Station, England, to initiate work in the almost unknown field of tropical soil microbiology, and the recent arrival of Mr. Eastop under a Colonial Office Research Fellowship, to study the biology and taxonomy of aphids in East Africa. The arrangement for associating certain members of the Overseas Food Corporation scientific staff with the E.A.A.F.R.O. research programme as detailed on p. 12 of the 1951 Report can also be considered under this head. It has worked throughout 1952 in a satisfactory manner. Also under this head is the secondment of Dr. Hursh under the Fulbright Act of the U.S.A., Dr. Hursh's report, which is discussed on p. 9 appears in full in pp. 26-35. In the present connection it is sufficient to point out that the full value to the territories of Dr. Hursh's visit and advice could not have been obtained without the centralised and co-ordinating facilities automatically provided by the existence of E.A.A.F.R.O. An example from another and less formal aspect of the same considerations is provided by the laboratory and housing facilities made available to Professor Stelly at the request of the Kenya Department of Agriculture, with whom Professor Stelly is working on a programme arranged by the Mutual Security Agency set up by the U.S.A..

Secondly, there are the various degrees of liaison between the actual researches conducted by different agencies. The importance of this cannot be over-emphasised. But it is equally important to understand that administrative or organisational machinery, no matter how well-intentioned, cannot of itself ensure such liaison. Indeed, in general, paradoxical though it may seem, the less the machinery the better the liaison: for liaison between agencies or institutes is merely the projection, in a number of directions, of the almost universal habit of individual scientists of making direct contacts with their opposite numbers on any aspect of their researches on which they want help or criticism. The machinery needed to cover, even in a broad manner, the many different kinds of liaison between research institutes, and between research workers, would be cumbersome and inefficient at best. In any case it does not seem very necessary to create machinery for doing what is already being done.

In the succeeding paragraphs a few of the more important items of liaison and integrated researches, selected from the separate Sectional Reports, have been assembled to show not only how co-ordination grows almost automatically as a constituent part of the research, but also the wide variety of the forms of co-ordination that are required. In addition to the instances given there are many other items of inter-sectional collaboration within the Organisation itself; of joint work between Research Organisations, such as the joint Animal Industry Division of E.A.A.F.R.O. and E.A.V.R.O.; and of mutual help in exchanging samples, etc.

Plant Breeding.—This is a very good example of co-ordination. In the first place the Specialist Committee on Plant Breeding and Genetics passes the whole of the East African plant breeding work under review, thus eliminating overlaps and — as far as the limited number of workers allows — closing gaps. In the second place, all opportunities for mutual assistance between workers and centres are taken, as the following examples show. The improved disease resistant types of cassava bred by E.A.A.F.R.O. at the Amani Station are undergoing trials, both on territorial department experiment stations and on private farms. Work is under way with the Overseas Food Corporation on the problems involved in inter-specific crossing of the economic varieties of groundnuts, susceptible to rosette disease, with non-economic but resistant types. The work on producing better maize varieties for use in the Native Land Units is being carried out in its initial stages in co-operation with the Kenya Department of Agriculture. A further striking example of swift collaboration in plant breeding for disease resistance is given in the next paragraph.

Plant Pathology.—In 1951 official warnings were issued in West Africa about a devastating rust disease of maize that had appeared there. Our own Plant Breeding Committee made immediate preparations. A collection of East African maize types was tested in West Africa and shown to have no resistance whatever. As soon as the disease was reported in East Africa a change in research programmes was made, and a co-operative plan of research between the Kenya and Uganda Departments of Agriculture and E.A.A.F.R.O. was begun for the intensive testing of disease resistance of introduced exotic varieties that may have immunity or high resistance, and the crossing of some of these with the susceptible East African types; this co-operative work is now well in hand.

Plant Physiology.—A further kind of liaison is shown by the pyrethrum investigations in this Section. The work was briefly outlined on p. 17 of the 1951 Report. In essentials it consists of a collaborative effort between the Plant Pathologist of the Kenya Department of Agriculture and the Plant Physiologist, E.A.A.F.R.O. for the study of the "bud disease" of pyrethrum, with funds provided by the Pyrethrum Board of Kenya. To quote from the 1951 Report: "This work is a good example of the value of an inter-territorial research organisation that has available experienced research officers for tasks of this kind. It was not necessary for the Board to go to the expense (and the difficulty) of engaging a research worker for a term, but only to provide the relatively small amount needed for an extra scientific assistant to help in the laboratory, glasshouse and field work." The further year's experience since that was written has confirmed the effectiveness of the simple arrangements for co-ordination originally made.

Insecticides Research.—This work is essentially a co-operative effort between two research organisations: the Empire Cotton Growing Corporation Cotton Research Station Laboratory at Namulonge, Uganda, and E.A.A.F.R.O. The E.A.A.F.R.O. officer, Mr. McKinlay, has been stationed at Namulonge from the time of his first appointment to E.A.A.F.R.O. and has worked throughout in the closest touch with the Namulonge staff on the use of insecticides

for the cotton plant. Reference should be made to the Sectional Report on p. 46 for an account of the work. Although it is confined to cotton at present, this crop is grown under peasant farming conditions, so it is expected that the work will be applicable, without drastic modifications, to other peasant-grown crops.

Soil Physics.—The programme of this Section is almost entirely collaboration, as the investigations are being made either with, or for, territorial departments. Dr. Pereira is continuing his former work at the Coffee Research Station, Ruiru, where, before transfer to E.A.A.F.R.O. he was in charge of the Soil Science Laboratory. He is also studying some of the soil structure effects of various crop rotations, jointly with territorial officers in Uganda, and at Kongwa in Tanganyika on the Overseas Food Corporation farms. This latter is part of the Overseas Food Corporation programme executed in association with E.A.A.F.R.O. In Kenya a joint study with territorial officers is being completed; the problem is the effect on soil structure of the grass-establishment experiments on the badly eroded soils near Machakos.

Soil Chemistry.—The example chosen under this head illustrates very well the point, made above, that co-operation and co-ordination are an almost automatic consequence of the practice of direct contacts between scientific workers. Dr. Birch's researches on the factors responsible for the degree of crop response to phosphate fertilisers in East African soils have brought order into what was a complex — indeed, almost chaotic — problem. After direct correspondence with Dr. Birch, the Ministry of Agriculture of Southern Rhodesia is applying his concepts and methods in place of those hitherto used, which gave no satisfactory explanation of their field results.

Soil Microbiology.—In the exploratory study of soil micro-organisms, already mentioned, a joint study with the Uganda Department of Agriculture specialists is being made of factors responsible for the accumulation of nitrate in the soil. This problem, especially the practical aspects of making the best agricultural use of the nitrate, has been under study in Uganda for some years. The E.A.A.F.R.O approach to the same problem lies more in the sphere of studying the nitrogen cycle in tropical soils, to ascertain what natural level of nitrogen content might be expected from the normal biological activities in our soils; until this is known it is not possible to say with any confidence whether it is desirable — and, if desirable, feasible — to attempt to raise the inherent fertility level of East African soils by agricultural operations that would increase the humus content. This combined research shows yet another of the many different kinds of co-ordination that develop: in this case, a basic research into the fertility status of tropical soil is combined with an agronomical investigation having a strong practical aspect.

Soil Survey.—When rapidly mounting costs from 1947 onwards made it clear that the early estimates of total scientific staff for E.A.A.F.R.O. had to be very considerably reduced, it was decided that work on the Soil Map of East Africa would have to be combined with work on specific areas in the territories where, for economic reasons, some form of development was contemplated. This latter

kind of survey includes many other factors besides the soil characteristics used in a standard soil survey, and requires to be done jointly with agricultural officers of the territory concerned. In the 1951 Report examples were given so it is unnecessary to repeat them here.

Chemical and Spectrographic Analyses.—A number of varied activities involving some form of co-operation or direct assistance can be found in the work of this Section. In the past year such services have been rendered to the Government of British Somaliland, the Tanganyika Sisal Growers' Association, the Overseas Food Corporation, the East African Fishery Research and the Department of Agriculture, Tanganyika.

Statistics.—All territorial Departments of Agriculture have been helped in the design and analysis of experiments. In addition other organisations have been helped in problems ranging from pruning experiments of a Forestry Department to the possibility of using data from locust populations to determine the origin of migrating swarms.

Forest Entomology.—Two African rangers, after training by Mr. Gardner at E.A.A.F.R.O., are engaged on forest insect survey work in Uganda. This arrangement is working very well. One European forester of the Kenya Forestry Department is working under Mr. Gardner's guidance, and the Department is arranging for a considerable increase in staff for this co-operative work, including an entomologist and several foresters and rangers.

The forms of co-ordination discussed above cover so many different items that a summary is hardly feasible. Under the head of administrative machinery the examples of co-operative work include the attached C.D. & W. schemes; a Colonial Office Research Fellow; a secondment from the Rothamsted Experimental Station; the Overseas Food Corporation; and a Fulbright Research Scholar from the U.S.A. Under the second and important head of liaison between E.A.A.F.R.O. investigations and others, the examples cover such matters as joint work with territorial departments; the dividing-out of technological investigations between E.A.A.F.R.O. workers and others; the combining of an E.A.A.F.R.O. basic research with an agronomical investigation in a territory. Although it is not included in the above examples, mention may be appropriately made in this summary paragraph of a further form of liaison: a most successful Forestry course held in November, and attended by Forestry Department officers from all three territories (see p. 56).

Finally, the general co-ordination of the whole of the East African work with that in the rest of the Colonial Empire, is kept under review by the Colonial Office Committee for Colonial Agricultural, Animal Health and Forestry Research. Besides the normal continuous reviews, made in committee and sub-committees, one meeting a year, which is attended by the Director, is devoted to detailed discussion of past work in East Africa, and of present and proposed future programmes. This meeting provides a very valuable opportunity for securing full consideration of the East African viewpoints.

(IV) C.D. & W. Schemes Attached to E.A.A.F.R.O.

Termite Research Scheme.—In accordance with the original programme Mr. Harris has moved his headquarters to the Commonwealth Institute of Entomology, London, where he can give the special attention to systematics and classifications that is now required. Mr. Sands is conducting the experimental work at E.A.A.F.R.O. and is paying special attention to the ingestion and rate of movement of food in the alimentary canal, using tracer materials such as dyed and pigmented food and powdered charcoal. Collection of material for systematic study has been actively continued in East Africa, and visits were also made to St. Helena, and, by arrangement with the Belgian authorities, to Ruanda-Urundi. The ecological survey of the termites of north-eastern Tanganyika was completed by Miss Kemp before her resignation at the end of September.

Ecology Training Scheme.—It was not until the end of September that this Scheme came into full operation, with the arrival of two Research Students and one Agricultural Probationer. Thanks to extensive preliminary tours and studies by Mr. Trapnell, it was possible to begin the training at once. The area selected was the important West Uganda Rail Link Extension zone between Mityana and Lake Edward. A reconnaissance vegetation survey was made of this area in order to provide the information on which future proposals for agricultural and other land developments have to be based. This survey brought out widespread indications of deterioration of former grazing areas.

Climatic Data in Relation to Agriculture.—Mr. Walter has completed the test of his formula, employing the long run of records available at Kew Observatory, England, and has completed part of his final report, which will in due course be utilised in the meteorological and soil physics studies at Muguga. This report is necessarily lengthy and, as it is not yet completed and cannot be effectively summarized, a separate account is not included this year.

(V) Staff

During the year the resignations included the Secretary and the Librarian. The following research officers joined the staff: Dr. Pereira, Soil Physicist; Mr. Stuart, Silviculturist; Mr. Friend, Analyst. Arrangements were also completed for the appointment of Dr. French as Head of the joint Animal Industry Division, and he assumed duty in October. Dr. Duthie, on return from leave, has moved into the Animal Industry Division as Biochemist, while still retaining the Editorship of the East African Agricultural Journal. Dr. Rudd Jones was awarded a Post-doctorate Fellowship of the Canadian National Research Council.

The making of a new C.D. & W. Scheme for the completion of the ten-year programme (the capital part of which is mentioned on p. 6) allows, on the recurrent side for two, possibly three, additional research officers, for the staff of the joint Animal Industry Division and for a Soil Microbiologist. When the Scheme is complete, the

research officer strength will be about 25. In 1947, when the Scheme was drawn up, it was expected that 45 research officers could be carried on the very budgets to which we are now working. In view of the ever-rising costs, the Scheme was recast, and by concentrating on the higher priorities, the research officer total was reduced to 35. This number, moreover, was seen to be the minimum consistent with the retention of a reasonably balanced programme. The difference between 35, the accepted minimum, and 25, the practicable maximum, would be far more serious than it is, but for the two attached C.D. & W. Schemes, the arrangement with the Overseas Food Corporation, and the temporary service of officers from other organisations, already mentioned on p. 12 of this Report. Nevertheless there must be a degree of improvisation in any arrangement that bridges the gap between 25 and 35 by temporary means of this kind. While it is true that the attachment of a Scheme or of an individual officer to E.A.A.F.R.O. is effected primarily because the proposed programme is closely related to the E.A.A.F.R.O. programme, the temporary nature of some of the attachments, and the wide variation in their proposed programmes, make for a considerable element of chance in the attempt to keep the combined programmes in reasonable balance.

Reference was made in last year's Report to the delay in implementing the new Colonial Research Service. Although the Service was brought into operation during 1952, transfers to it are still held up by difficulties over the interpretation of the terms of the Colonial Superannuation Scheme.

The Director was created a Knight Bachelor in the Birthday Honours List, 1952, and Dr. F. J. Nutman was awarded the O.B.E. in the New Year's Honours List, 1953.

Publications

A Complete List of Scientific Papers from the East African Agriculture and Forestry Research Organisation from its Establishment in January, 1948, to the End of 1952

A limited number of offprints of most of the following papers is available. Application should be made to the Librarian.

Birch, H. F. (1948) Soil phosphates — a review of the literature. *E. Afr. agric. J.*, **14,** 29-32.

Birch, H. F. (1951) Relationships between base saturation and crop response to phosphate in acid soils. *Nature, Lond.*, **168,** 388-389.

Birch, H. F. (1952) The relationship between phosphate response and base saturation in acid soils. *J. agric. Sci.*, **42,** 276-285.

Birch, H. F. and L. R. Doughty (1948) The distribution and inter-relationships of the alkaloids in the bark of *Cinchona Ledgeriana*. *Biochem. J.*, **43,** 38-44.

Black, I. A. (1950) Theoretical errors of hydrometer methods for the mechanical analysis of soils. *J. Soil Sci.*, **2,** 118-133.

Black, I. A. and E. Smith (1950) Routine determination of exchangeable bases in soils by the Lundegardh flame spectrographic method. *J. Sci. Fd. Agric.*, **1**, 201-208.

French, M. H. (1952) Cattle concentrates. *E. Afr. Field, Farm and Garden,* **19,** 24-25.

French, M. H. (1952) Mineral deficiencies in farm livestock. *E. Afr. agric. J.*, **18,** 4-8.

French, M. H. (1952) Mineral deficiencies in farm livestock. *E. Afr. Field, Farm and Garden,* **19,** 28-30.

Glover, J. (1948) Water demands of maize and sorghum. *E. Afr. agric. J.*, **13,** 171.

Glover, J. (1952) Calculations of the wetness of air. *E. Afr. agric. J.*, **17,** 162-65.

Glover, J. and H. H. Storey (1949) Research on agriculture in semi-arid regions. *Afr. Regional Sci. Conf., Johannesburg,* **2,** 165-166.

Greenway, P. J. (1948) The paw paw or papaya. *E. Afr. agric. J.* **13,** 228-233.

Greenway, P. J. (1950) Vegetable fibres and flosses in East Africa. *E. Afr. agric. J.*, **15**, 146-53.

Greenway, P. J. and B. Verdcourt (1952) Notes from E.A. Herbarium. *Kew Bull.*, **1952,** 353-365.

Griffith, A. L. (1950) The great Indian desert. *Proc. Nairobi Sci. and Phil. Soc.*, **5,** 17-24.

Griffith, A. L. (1951) Aerial reconnaissance for the District Officer. *Proc. Nairobi Sci. and Phil. Soc.*, **6,** 21-22.

Griffith, A. L. (1951) East African enumerations. The Rondo Plateau (S. Tanganyika). *Emp. For. Rev.*, **30**, 179-182.

Griffith, A. L. (1951) Notes on some Conifer nurseries in the South and West of the U.S.A. *E. Afr. agric. J.*, **17,** 32-34.

Griffith, A. L. (1951) Watershed management research in the U.S.A. *E. Afr. agric. J.*, **16**, 190-197.

Griffith, A. L. (1951) Watershed management in the U.S.A. *Proc. Nairobi Sci. and Phil. Soc.*, **5,** 59-67.

Griffith, A. L. (1952) The Abidjan Forest Conference — December, 1951. *E. Afr. agric. J.*, **17,** 201-202.

GRIFFITH, A. L. (1952) East African enumerations. *Pterocarpus angolensis* in mixed woodland. *Emp. For. Rev.*, **31**, 146-149.

GRIFFITH, A. L. (1952) The forest dedication scheme of the Buganda Province of Uganda. *E. Afr. agric. J.*, **17**, 203-204.

GRIFFITH, A. L. (1952) Watershed management in the U.S.A. *Emp. For. Rev.*, **31**, 103-114.

HARRIS, W. V. (1950) Dry wood termites. *E. Afr. agric. J.*, **16**, 50-52.

HARRIS, W. V. (1951) Further records of East African termites. *Proc. R. ent. Soc. Lond.*, B, **20**, 25-28.

HARRIS, W. V. (1951) The ubiquitous termite. *E. Afr. agric. J.*, **17**, 60-62.

HARRIS, W. V. (1952) A note on wood preservatives for termite control. *E. Afr. agric. J.*, **17**, 109-110.

KEEN, B. A. (1949) The effect of mechanical cultivation on soil degradation. *Bull. agric. Congo belge*, **40**, 2003-2009.

KEEN, B. A. (1949) Economic and social aspects of co-operative and collective farming systems. *Bull. agric. Congo belge*, **40**, 2451-2455.

KEEN, B. A. (1949) The guessers and the accumulators. *Proc. Nairobi Sci. and Phil. Soc.*, **3**, 22-28.

KEEN, B. A. (1950) Applications of simple conservation and utilisation practice. *Proc. U.N. Sci. Conf. Conservation and Utilisation of Resources*, **1**, 216-218.

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KEEN, B. A. (1951) Tillage in relation to soil conditions and plant growth. *Proc. Conf. Plant and Animal Nutrition in relation to soil and climatic factors.* Australia, 46-50.

KEMP, P. B. (1951) Field observations on the activity of *Pheidole*. *Bull. ent. Res.*, **42**, 201-206.

KEMP, P. B. (1951) The susceptibility of wood to termite attack. *E. Afr. agric. J.*, **16**, 122-123.

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McKinlay, K. S. (1952) Phytotoxicity of BHC to cotton. *Emp. Cott. Gr. Rev.*, **29,** 269-272.

May, W. B. (1949) Horticultural work with the Clove tree in Zanzibar. *Gdnrs' Chron.* **125,** 178-179.

Nichols, R. F. W. (1950) The brown streak disease of cassava. *E. Afr. agric. J.*, **15,** 154-160.

Nutman, F. J. and F. M. L. Sheffield (1949) Studies of the Clove tree. I. Sudden-death disease and its epidemiology. *Ann. appl. Biol.*, **36,** 419-439.

Nutman, F. J. (1950) Studies of the Clove tree. III. The effect of sudden-death disease on water relations. *Ann. appl. Biol.*, **37,** 584-490.

Nutman, F. J. and F. M. L. Sheffield *et alia* (1951) The sudden-death disease of cloves and its economic and agricultural significance. *Emp. J. exp. Agric.*, **19,** 145-159.

Pereira, H. C. (1952) Interception of rainfall by Cypress plantations. *E. Afr. agric. J.*, **18,** 73-76.

Pereira, H. C. (1952) Restoration of structure in eroded coffee soils. *Mon. Bull. Coffee Bd. Kenya,* **17,** 202-203.

Robb, R. I. (1950) Laboratory trials with some of the newer insecticides against a scale insect (*Saissetia* species). *E. Afr. agric. J.*, **15,** 227-228.

Sheffield, F. M. L. (1950) The Clove trees of the Seychelles. *E. Afr. agric. J.*, **16,** 3-8.

Sheffield, F. M. L. (1950) Studies of the Clove tree. II. Histology with special reference to sudden-death disease. *Ann. appl. Biol.*, **37,** 23-45.

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Storey, H. H. (1949) Research on virus diseases of plants. *Afr. Regional Sci. Conf., Johannesburg,* **1,** 168-170.

Storey, H. H. (1951) Basic research in agriculture: a brief history of research at Amani, 1928-1947, Nairobi, 24p.

Trapnell, C. G. (1951) Uses of aerial photography in vegetation, soil and land use surveys. *Proc. Nairobi Sci. and Phil. Soc.*, **6,** 17-20.

Verdcourt, B. (1948) Biological flora of the British Isles: *Cuscuta* and *C. europaea* L. *J. Ecol.*, **36,** 356-365.

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VERDCOURT, B. (1952) Notes on some Neuroptera from Nairobi, Kenya. *Ent. mon. Mag.*, **88,** 204.

VERDCOURT, B. (1952) Notes on the snails of North-East Tanganyika Territory. *Proc. malac. Soc., Lond.*, **29,** I. 7-8, II-V. 205-209.

VERDCOURT, B. (1952) Revision of certain African genera of herbaceous Rubiaceae. I. The genus *Pentanisia* Harv. *Bull. Jard. bot. Brux.*, **22,** 233-286.

VERDCOURT, B. (1952) Two new species of *Pentanisia* from Kenya Colony. *Kew Bull.*, **1951,** 381-385.

VERDCOURT, B. (1952) Notes on Tropical African dodders. *E. Afr. agric. J.*, **18,** 85-86.

WAY, M. J. (1951) An insect pest of coconuts and its relationship to certain ant species. *Nature, Lond.*, **168,** 302.

Scientific Papers Submitted for Publication in 1952

BIRCH, H. F. Phosphate response, base saturation and silica relationships in acid soils.

BIRCH, H. F. The relationship in acid soils between base saturation and phosphorus uptake by grasses.

Chamberlain, G. T. Arc flame and spark. The uses of the spectrograph.

Eastop, V. F. Notes on East African aphids.

Glover, J. Nutrition of maize in sand culture. I. The balance of nutrition with particular reference to the level of supply of nitrogen and phosphorus. II. The uptake of nitrogen and phosphorus and its relevance to plant analysis.

Glover, J. and P. Robinson A simple method of assessing the reliability of rainfall.

Griffith, A. L. Some forest problems of East Africa.

Griffith, A. L. Statistical methods in forest research. Strip enumeration surveys.

Harris, W. V. A note on the termites of St. Helena.

Harris, W. V. The termite community.

Nutman, F. J. Note on the relationship between climatic factors and transpiration and assimilation of *Eugenia aromatica.*

Nutman, F. J. and F. M. Roberts The sudden-death disease of the clove tree. *Eugenia aromatica.*

Nutman, F. J. and F. M. Roberts Two new species of fungi on Clove trees in the Zanzibar Protectorate.

Nutman, F. J. and F. M. Roberts Severe dieback of cloves in the Zanzibar Protectorate.

Nutman, F. J. and F. M. Roberts The relation of *Valsa eugeniae* to the sudden-death of Clove trees in the Zanzibar Protectorate.

Nutman, F. J. and F. M. Roberts A history of investigations into the diseases of the Clove tree in the Zanzibar Protectorate.

Pereira, H. C. and V. A. Beckley Grass establishment on an eroded soil in a semi-arid African reserve.

Robinson, P. The distribution of plant populations.

Robinson, P. and T. M. Carey Manuring of sugar-cane.

Rudd Jones, D. Studies on a canker disease of Cypresses in East Africa caused by *Monochaetia unicornia* (Cooke and Ellis) Sacc. I. Observations on the pathology, spread and possible origins of the disease.

Way, M. J. Studies on *Theraptus* sp. (Coreidae) the cause of the "gumming disease" of coconuts in East Africa.

Way, M. J. Studies on the association of the ant *Oecophylla longinoda* (Formicidae) with the scale insect *Saissetia eugeniae* (Coccidae).

Way, M. J. Studies on the life history and ecology of the ant, *Oecophylla longinoda* Latrielle.

Way, M. J. The relationship between certain ant species with particular reference to biological control of the Coreid *Theraptus* sp.

Popular Articles

Twelve articles by the staff of the East African Agriculture and Forestry Research Organisation have appeared in the East African Press.

Table of Muguga Rainfall

Numerator: Ins. Rain

Denominator: No. of rainy days.

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Average	1.07 / 2	1.73 / 3	3.83 / 8	8.71 / 16	8.27 / 15	1.42 / 5	0.54 / 1	0.69 / 2	1.17 / 2	1.99 / 6	3.93 / 9	3.21 / 7	36.56 (for 34 years) / 76 (for 19 years)
Average running Total	1.07 / 2	2.80 / 5	6.63 / 13	15.34 / 29	23.61 / 44	25.03 / 49	25.57 / 50	26.26 / 52	27.43 / 54	29.42 / 60	33.35 / 69	36.56 / 76	
1952	0.41 / 3	1.81 / 6	2.11 / 4	10.16 / 18	12.83 / 23	0.05 / 1	0.73 / 8	0.54 / 8	3.29 / 8	1.38 / 8	2.48 / 15	0.82 / 6	36.61 (normal) / 108 (42% over normal)
1952 running Total	0.41 / 3	2.22 / 9	4.33 / 13	14.49 / 31	27.32 / 54	27.37 / 55	28.10 / 63	28.64 / 71	31.93 / 79	33.31 / 87	35.79 / 102	36.61 / 108	

Note.—The number of rainy days (0.01 in. or over) both for 1952 and 1951, so much exceeded the average as to raise some doubts whether the pre-1951 determinations included all the rainy days. The E.A. Meteorological Department found no conclusive evidence that this was the case, so the full range of data has been used in averaging.

Library

Staff

L. D. Verdcourt ..... *Librarian*

The nucleus of the present E.A.A.F.R.O. Library was formed in German East Africa by the Biologisch-Landwirtschaftliches Institut and developed at Amani by the East African Agricultural Research Institute. This year marks the first uninterrupted year in the new and spacious building at Muguga, the permanent home of the Library.

Mrs. Verdcourt started working in the Library in May and took over duties from Miss Ossent, who went on retirement leave in June. Other staff consists of two African Assistants undergoing training.

The purpose of a Library of this type is to make the material readily available for use; and in order to fulfill this purpose, it is essential that the books are adequately classified, and the catalogues are accurate and complete. If this is not done, much valuable material may be "lost". The existing classification scheme which was developed at Amani is sufficiently flexible to meet the expanding needs of the Library; it is regrettable, however, that it is not an international system, and at some future date it may be possible to undertake the very heavy task of changing over.

The first need after the move from Amani was to get the books on the shelves and available to readers. During 1952, this work was completed and to facilitate the finding of books a ground plan and a list of the main headings of the classification scheme are exhibited at the entrance to the Library. Besides routine of catalogues and indexes, every effort is being made to check that these are a complete record of all that exists in the Library. The inter-library loan service which had been dislocated by the transfer was re-opened and 76 publications were sent on loan and many publications obtained from the U.S.A., Great Britain and South Africa.

The Library is fortunate in having a self-contained bookbinding unit. The Amani bookbinders moved to Kenya with the Librarian to help establish a bookbindery and, when the unit was firmly established, returned to their Tanganyika homes. A local African bookbinder has now taken charge of the staff of four boys and the output is steadily increasing. Arrangements were made to bind several hundred books belonging to E.A.V.R.O., the Library of which will be amalgamated with this one in 1953.

One of the duties of the Librarian is to despatch the Annual Report of the Organisation: in 1952 nearly a thousand reports were sent out, as well as many reprints of scientific articles by research staff. Once again the mailing list was revised and brought up to date in co-operation with the research officers.

The Library is now receiving nearly 500 periodicals from 23 different countries, including 13 new titles this year. Rising prices have made it necessary to reduce the number of purchased periodicals. Preparation of a list of these and an analysis of current prices occupied much of the Librarian's time, since records were incomplete. The Library Committee, in consultation with research officers, was then able to eliminate a number, the loss of which would not seriously detract from the value of the Library in its capacity as the largest scientific reference library in East Africa.

Work started on the large collection of duplicate issues of periodicals will continue in 1953. After a complete check, they are to be indexed and a list published for circulation to other libraries in East Africa. Those that cannot be exchanged or distributed in Africa, will be despatched to the U.N.O. clearing house for publications in Paris.

E.A. Agricultural Journal

STAFF

D. W. Duthie ..... *Editor*
H. C. Pereira ..... *Editor, April to November,* 1952
Miss J. Nutman ..... *Business Manager*

During Dr. Duthie's absence on overseas leave from April to November, Dr. H. C. Pereira carried on the editorship of the Journal. Miss Nutman, who was appointed with effect from 1st January, 1952, resigned at the end of November because of her forthcoming marriage.

Some delays in publication were unavoidable at the beginning of the year, as some form of financial guarantee from the Governments of Kenya, Tanganyika and Uganda was necessary before the publication could be continued. In consequence, the January and April numbers could not be sent to press until May, and some difficulty was experienced in making up for this lost time.

At the January, 1952, meeting of the East African Advisory Council on Agriculture, Animal Industry and Forestry, the future of this Journal was discussed at some length. It was recommended that the present form of the Journal should be retained, and that the three East African Governments should be asked to provide funds every year to cover the financial deficit. In addition, Council suggested that a Committee should be set up by the High Commission to investigate the possibilities of reducing the expenses of production and increasing the revenue. This Committee met later in the year, and its report was accepted by the three territorial Governments without modification.

One point which emerged during the discussion by the Advisory Council was that several technical departments in the three territories do not subscribe to sufficient copies for all their officers to have easy access to the Journal. It is satisfactory to record that there has since

been a noticeable increase in the subscriptions from these departments It is desirable that every technical officer should be able to consult the Journal without difficulty, and it is hoped that this objective will be reached in the future. Several questions were raised on the financial background of the Journal and the opportunity was taken to review its financial and editorial history since its publication was first suggested in 1936; this review appears as an editorial article in the January, 1952, issue (Vol. 17, No. 3).

In June, at the Royal Agricultural Show in Nairobi, the East African Agricultural Journal was advertised in a stand which attracted considerable attention. Many copies of the current issue were sold and a number of additions were made to the list of regular subscribers. Thanks are due to the Director of Veterinary Services, Kenya, who provided display and other facilities in his departmental stand for the main Journal exhibit, and also to the Director of Agriculture and the Conservator of Forests, who gave it publicity on their stands.

There has been an increase in the number of subscribers, the total at the end of 1952 being 1,305, as compared with approximately 1,200 at the end of 1951. The geographical distribution of the present subscribers is as follows: Kenya 478; Tanganyika 241; Uganda 143; West Africa 291; North and South America, including West Indies 50; Great Britain 22; rest of Europe 24; India, Australia and the Far East 56. The free and exchange list includes 55 copies to Great Britain, 22 to the rest of Europe, 42 to India, Australia and the Far East, 41 to North and South America and 21 to Africa, excluding British East Africa. These figures show the world-wide interest in the Journal, 624 copies going to countries outside the three East African Territories. The editorial policy must take this into account when balancing the claims of popular articles of local interest against those of technical articles of the high standard which has been established over the seventeen years of the Journal's life.

Forest Management in East Africa in Relation to Local Climate, Water and Soil Resources

Report and Recommendations

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Foreword

The provisions of the Fulbright Act enabled the writer to spend the year 1952 in East Africa, with headquarters at the East African Agriculture and Forestry Research Organisation. The major part

of the time was spent in the field, and the help of the Forestry Departments of Kenya, Tanganyika and Uganda in many directions is hereby acknowledged. The objective was to make a survey of research needs and other pertinent problems in the field of forest management as it relates to local climate, water and soil resources. In making this survey, representative land-use problem areas were visited in all the three territories. A summary of some of the general conclusions drawn from this survey is given below.

Basic Land Resources a Mutual Responsibility

Forest management plays an important part in the control of the three basic land resources, local climate, soil and water.

In Equatorial Africa protection of cultivated crops from the disastrous effect of climate is a major consideration in developing methods and systems of land use. The shifting cultivation practised by the native in forest areas is a fairly successful attempt to utilise the beneficial effect of trees in growing food. Under more intensive use of the land today, it is even more necessary to develop systems of land use that will have some of the same advantages as shifting culture in overcoming the damaging effect of the equatorial climate on exposed mineral soil. Some of these systems are already well developed, for example, the use of windbreaks and canopy protection for tea and coffee, also the use of nurse crops, mulches, etc. Tree shelter belts have been employed in a few cases to protect exposed fields and farm buildings.

The maintenance of forests and other natural vegetation for the benefit of local climate and water resources has not been given any real consideration in major land development programmes. All such programmes require the integration of skills in the fields of forestry, crop production and range management. A frequent lack of such co-operation has doubtless resulted in unfortunate and costly mistakes in East Africa. The situation arises from the failure of specialists themselves, as well as land administrators, to acquire a working knowledge of the natural processes that determine favourable soil, water and climate relations, and for which they all have an equal professional responsibility. This common responsibility for basic land resources is the logical meeting ground for all who have a part in the development of the country. East Africa has an urgent need for combined skills in formulating programmes for the restoration and maintenance of depleted land resources.

Expansion of Farm Foresty Needed

An example of the need and opportunity for integrated land utilization is found in the field of farm forestry. The value of trees for the protection of other crops from climatic stress has been proven the world over and of course is well recognised for special crops in East Africa. Nevertheless the beneficial uses of forestry have generally been overlooked in a hasty effort to increase food and forage production. Intensive modern machine cultivation has been

imposed on large tracts on which there has been wholesale and indiscriminate clearing of natural vegetation. This has been done without due consideration being given to the possibility of soil sterilizing effects, high temperatures, extreme desiccation and severe wind erosion. These extremes must be modified locally by forming windbreaks and leaving blocks of trees as an integral part of the cropping system.

This concept of practical farm forestry is especially needed in any sound programme for increased production of equatorial crops and grasslands. Through judicious management, wood products from farm forestry furnish a very profitable return in addition to the ecological value the trees have in improving local conditions for crop growth. From fifteen to thirty per cent of all agricultural land should be maintained or rotated under some form of tree crop. The amount of land needed in trees will differ depending on local climatic situations, but generally speaking marginal and severe climates require a greater area of trees.

Improvement of Damaged Local Climates

Unfortunately the subject of improving the local climate has given rise to much needless controversy. The reason is due chiefly to the lack of a common understanding of definitions and basic concepts of climate. Major climates of a country are determined by latitude, proximity to the ocean, topographic features, and by great geophysical forces such as seasonal wind currents and polar air masses. Naturally land use does not have any immediate effect on climate as defined above. However, within specific localities the different elements of climate are definitely modified through man's activities. A simple illustration is the control of wind and transpiration in tea plantations through the use of wind-breaks and tree canopy protection. Thus, it is the local climate which we modify through land utilization. In East Africa local climate has already been modified unfavourably by unplanned cutting of the forests and by exposing the soil over vast areas of range land through overgrazing, trampling and burning.

The Southern Highlands, Tanganyika

The Southern Highlands of Tanganyika are a good example of a large area where the damaged local climate can be greatly improved by practical measures. Here wind-breaks and tree canopy protection have been used by tea-growers on the Mufindi escarpment for several decades. At present the high forest is being re-established, adjacent to the tea paddocks, for the purpose of conserving the mist. The effectiveness of this mist, so desirable for local tea production is believed by the growers to have changed during past years because of the excessive removal of the high forest. The present interest is not only to restore the forests adjacent to the tea estates but to extend the mist belt still further westward by establishing new forests in the open grasslands.

At the start, forest re-establishment should be contiguous with the existing high forest and should be in quite solid blocks. After

a period of years, a portion of the new forest can be cleared in small paddocks for special crops without seriously affecting the amount of mist. Extending the mist belt clear across the Highlands is a possibility; however, some of the land has poor soils which present problems in finding the right tree species and developing planting techniques.

For the Southern Highlands as a whole, existing forests are too limited to meet the critical local needs for the control and betterment of climate. Further cutting of the limited amount of high forest areas must be sharply restricted until a much larger reserve of forest areas has been established. There are at present a number of comprehensive climatic improvement schemes under consideration. These schemes are obviously sound in principle because the whole of the Highlands region is known to have supported a dense forest at one time. However, the present soils of a considerable portion of the region are now unproductive because of leaching and complete exhaustion under native cultivation. Teams of technicians will be required for the overall planning and the selection of species and tree planting methods.

The native reserve within the Njombe triangle is a good example of a land area where a large-scale climatic improvement programme is imperative. Such a programme is indeed feasible and is already under consideration by the native chief and the District Commissioner. It is a large undertaking, but there are no major technical difficulties that cannot be overcome. The initial step would call for both planting of trees and the establishment of closed strips amounting to at least twenty per cent of the land area. Here the natural bush would be allowed to grow back under absolute protection from fire and livestock. Portions of these strips could be cleared for new shamba cultivation after two decades. Because there is no tsetse fly in this locality the rejuvenation of the bush is not a problem. The protected strips will serve the purpose of augmenting the beneficial effects of the forest wind-breaks, and in time they too will be partially planted in tree crops. Because of local needs for wood products, tree planting promises a profitable return. Consequently the cost of climate improvement will be restored to the district through needed wood products.

Apart from the Southern Highlands proper, one observes that large blocks of dry forest have been cleared for intensive machine cultivation without consideration of how this will affect the climate of the cleared areas. Extreme desiccation and erosion of the soil has resulted from the increased velocity of the wind sweeping over these large fields. Also the long furrows, ploughed directly into the wind (such as one sees today along the main road between Morogoro and Mvomero), facilitate the soil movement by the wind. More imaginative clearing of the original forest, such as leaving properly patterned wind-breaks, would not restrict the use of machines and would improve crop production. Here was a locality where forest management for local climate control should have been planned by the agronomists in charge and the local foresters.

The above example suggests strongly that the management and conservation of all dry forest types should be primarily the responsibility of foresters. Certainly the land policy should be determined by foresters in co-operation with other specialists if local climate and soil values are to be maintained or improved. In East Africa, the 20″ to 40″ rainfall areas have a natural ecological plant succession that becomes stable under a tree economy. Grazing and cultivation are efficient here only when practiced intensively. It is the unplanned, extensive use of the dry forest for nomadic grazing and sporadic cultivation, associated with constant burning, that has produced the frightful examples of land deterioration in East Africa. The dry forest will become more and more important for potential resettlement areas. It is not too early to plan for its gradual rehabilitation through exclusion of the present types of use which are leading to further deterioration.

Land Resource Management in the Karamoja District of Uganda and Adjacent Grazing Areas

The Karamoja District of Uganda and adjacent grazing areas are made up for the most part of land that has been exploited to the point of exhaustion. The region is pointed out as being one in which active desert encroachment is taking place because much of the soil has become bare of weed or grass cover within the memory of the inhabitants. Desert succulents have become more conspicuous. Erosion is still active, but the top soil has already been blown or washed away in wide areas. Surface storm water is cutting channels still wider and deeper with each rain where the topography has definite drainage lines. On more level areas surface storm-water flow is evident by the occurrence of frequent parallel sand-filled drifts and washes that increase in number during rain periods.

Native livestock is still present although it must range over great distances for forage and water. Some of the most damaged areas are only visited by the livestock infrequently, but these infrequent visits are enough to prevent regeneration of a vegetative cover. Under existing land conditions, it is obvious that the water balance has been greatly altered in the past and is still changing. In terms of water economy, this region is moving towards progressive desiccation.

Due to the extent of the bare land the heat radiated from the soil increases the velocity and drying potentiality of the lower wind currents. Thus it is conceivable that further surface wind passing through this vast region will carry an increased desiccating effect into contiguous land areas lying in the direction of the prevailing winds. For this reason it may be said that in dealing with local climates dryness breeds dryness and moisture breeds moisture. In a broad sense this generalization is one well worth contemplating in terms of land utilization in tropical countries. It is certainly a generalization that is true for many sections of the northern portions of East Africa.

Over most of the Karamoja District, there are no remnants of the natural vegetation to suggest what the original land and

vegetative conditions were like. Some forests still exist in the higher elevations of the north-eastern boundary. The extension and protection of those forests would be a first step in the restoration of the land and climate resources. If the present denuded areas could be completely relieved of livestock for a period of years they would doubtless tend to grow back into some form of vegetative cover. Restoration of favourable water and climate conditions for the northern districts must start with the progressive increase in vegetative cover over large contiguous areas.

One frequently hears the statement that in these districts it would be possible to increase the amount of livestock by restricting grazing to half of the land area at a time. This simply means that by proper rest periods and rotation grazing, more forage could be produced and utilized efficiently. At the same time, the soil, the water balance, and the local climate will be improved and thus turn the present trend of deterioration toward the gradual restoration of land values.

The Karamoja and Turkana Districts are examples of the type of occupancy which flogs out the land even after it has already been completely exhausted. The most severe form of land punishment known is to subject an area of marginal rainfall first to cattle, then to sheep, goats and donkeys, and finally, to camels. Ample evidence points to the fact that this was the same sequence of land exploitation that created widespread desert conditions in parts of the Middle East Mediterranean countries. That this sequence of land degeneration is going on apace in East Africa, creates concern among those who recognize the situation.

Attempts have been made to distribute grazing by developing bore holes for new water supplies. However, these attempts will not greatly relieve the situation unless strict regulations are put on all nomadic grazing. This is only possible under the supervision of local resource-conservation officers who are given full authority for enforcement.

Research in the Karamoja District should follow simple steps that will lead to the orientation of specific land rehabilitation problems. One such step would be the fencing-off of a number of small, representative plots in different parts of the District. Only seasonal observations would be needed to isolate local problems of vegetation re-establishment. Similarly simple, inexpensive tests could be tried, aimed at expediting the establishment of a primary plant succession. In addition to protected observation plots, it would be highly desirable to have all forms of livestock completely excluded from several representative large blocks of land for a pilot-test demonstration. Widespread recovery, however, will not take place till special officers are put in control of all forage resources and given every possible authority and support needed in the programme of restoration of marginal pasture lands.

Catchment Management

The objective of catchment management is to produce and maintain the maximum quantity and good quality of water resources,

The water resources may be utilized as streamflow, stored ground water for pumping, field moisture available for plants, or as surface storage in lakes, ponds and reservoirs. Consequently in any discussion of catchment management it is imperative to state clearly which of the above types of water resources is being considered. The role of vegetation in catchment management will vary with differences in the nature and distribution of rainfall, soil depth, topography and other characteristics. It is not surprising therefore to find that the effect of forests and other vegetation on streamflow is a subject that has led to considerable misunderstanding. To avoid these misunderstandings, it is necessary to discuss the disposition of water, within a catchment area, in terms of the sequence of natural water-cycle processes whereby water enters and moves through the soil mass, or returns to the atmosphere through evaporation and transpiration. In problems of land utilization, it is also helpful to think of these processes in terms of a soil-moisture balance which emphasizes the field-moisture factor in the overall water cycle.

To be precise in matters of catchment management it is necessary to speak of an individual component of the water cycle with reference to the specific land position and the specific time or season. For example the effectiveness of a rain varies with the amount, intensity, prior moisture, surface conditions, etc. Thus, annual totals and averages of rainfall and runoff have little realistic meaning in interpreting local climate.

Difficulties also arise from over-generalization, that is, when data from one locality are applied to another where they do not fit. This is a natural mistake that is to be expected. Nevertheless it is a mistake that has given rise to numerous misunderstandings regarding the practical solution of local catchment-management problems.

Catchment Management in the Bamboo Forest, Kenya

A controversial catchment-management problem was met with during the present survey in the bamboo forest of the Aberdares. The question was, "what would be the effect of replacing bamboo with plantations of softwoods where the object of catchment management is to obtain maximum ground-water recharge?" In this case the most important water-cycle measurement is the seasonal march of field moisture under comparative stands of bamboo and softwood plantations. Since ground water recharge takes place only when there is no field-moisture-saturation-deficit within the soil mass, the key to the problem is the number of days in the year when the soil mass is at field capacity and additional rainfall available. Recognizing this solution to the problem, Dr. Pereira, soil physicist for E.A.A.F.R.O., has taken continuous measurements of soil moisture at different depths throughout the soil mass under comparative bamboo stands and forest plantations. The records show that the roots of bamboo produce a more rapid exhaustion of soil moisture than do the tree roots. Consequently the soil remains below field capacity for a greater number of days in the year under bamboo. When new rains begin, a greater amount of water is needed to meet the requirements of this greater soil-moisture deficit. Because the soil under softwoods require less rain to maintain field capacity a

greater amount of ground-water recharge will take place here than under bamboo.

It would thus appear that catchment management may well include clearing bamboo and planting softwoods without detriment to ground-water resources of the region. Actually there would be a very significant reduction in transpiration on the cleared areas at first. If a rotation were followed whereby some clearing were made each year this would result in a useful increase in ground-water recharge.

Pending the outcome of field studies, cutting of bamboo for conversion to softwoods has been restricted. In the opinion of the writer, the results of these studies are already sufficiently clear to call for a new appraisal of the situation in order to draw up a technically sound catchment-management plan.

Catchment Management in the Shimba Hills, Kenya

The object of catchment management in the Shimba Hills is to obtain maximum, sustained water yields in streamflow and ground water for pumping. The question to be answered is, "what type of vegetative cover is most suitable for reaching this objective?" The answer to this question is more complex than in the bamboo forest. A portion of the Shimba catchment is occupied by small blocks of a five-storey rain forest, relics of an original forest that covered the whole area. The remainder of the catchment now supports only a very thin growth of Andropogon grass. At a distance this open land gives the impression of having an adequate grass cover. On close inspection, however, one finds that the grass clumps occupy less than forty per cent of the ground surface, so that most of the soil is actually without any protection. After the fires that annually sweep the catchment the land is totally exposed.

The soil mass was stated in government reports to be a deep porous sand through which water could pass directly to the underlying ground-water aquifer. Actually the sandy soil goes down to about five feet where an exceedingly impervious clay zone occurs. Clay zones of this kind retard percolation of free ground water and hold it close to the surface so that when other conditions are favourable to rapid evaporation from exposed soil, it goes right back into the atmosphere instead of contributing to the ground-water recharge.

In comparing the effects of forest and grassland on the Shimba Hills one must consider the soil-moisture balance. The key to the problem is the comparative percolation during periods of accumulated rainfall in excess of current daily losses. In this regard it is only necessary to demonstrate that percolation of free ground water is greater under the high forest because of deeper root penetration through the clay horizons of the soil profile. Obviously, transpiration is greater from the high forest but this is more than overbalanced by the much greater evaporation from the sparsely covered grasslands where moisture is held close to the surface. A short report on actual measurements in the Shimba Hills is in the course of preparation. There is more canopy interception loss in the high

forest, but this is many times offset by additional recharge to the water economy of the forest from mist, dew, fog drip, and related processes. For example, it has been found that in a somewhat similar coastal forest in Oregon these processes accounted for 11.23 inches of extra water in 142 foggy days.

The Shimba Hills are not natural grasslands. Originally there was a closed forest, remnants of which still exist. The present grasslands have been created from land once under cultivation, then abandoned and burned over continuously. They are still being maintained by annual fires. The grass that persists is not desirable for game or livestock and furnishes a very inadequate cover for water conservation. It would be impossible to maintain a really good grass cover in this area without regular mowing, grazing, or burning, or a combination of the three. A more reasonable alternative would be to return the entire area to a commercial high forest and then to regulate the stand density by selective harvesting.

A certain amount of riparian cutting would be immediately beneficial and this should be included in a catchment-management plan. At present a poor substitute for a grass cover is being maintained by fire where there should be a forest, and bush and trees are flourishing along the stream course where there should be a minimum of vegetation. Obviously, water conservation on the Shimba Hills can be achieved only through the operation of an overall catchment-management plan. At the present time there is no such plan and as a result water conservation operates in an entirely negative manner.

There are several reasons why such an unrealistic and negative land-administration policy exists there today. The principal reason is that a number of public agencies are concerned with the Shimba Hills and they do not view the problem of catchment management as one of mutual interest. Each agency has acted independently along lines believed best for its own interest, with the result that it has been impossible to have an integrated land-use programme. In consequence land conditions are becoming progressively worse each year for water-resource conservation. The only solution to this unfortunate situation is that an integrated management plan be drawn up for the Shimba Hills by the government agency which will have the responsibility and full authority for the administration of the plan.

Research Organisation

In the field of climate and water-resource management for East Africa, the greatest current need is for technological investigations, i.e. for the application of known research results. At the same time fundamental research must be intensified in certain directions. The above discussions, illustrating only a few of the types of problems, show that in every case the key to the solution lies in a study of the local water-cycle and soil-moisture balance.

The most important direction for such work would be water-cycle studies so devised as to be equally useful to the agronomist, the

range manager and the forester. Realistic analysis of meteorological and hydrological data is obviously needed in terms of specific localities and for comparative types of land utilisation; in other words, the analysis must be pin-pointed to give as specific an answer as possible to a specific question. To achieve this, the responsibility for devising the types of analyses most required, and the appraisal of the land utilization problems, must lie with the appropriate technological and research agencies; further, if these agencies do not themselves collect all the basic data, they should be empowered to state their requirements to those that do.

Only if the collection and interpretation of data pertinent to climate and water resources are organised in that way, can those charged with the formulation and development of land-use policies and programmes expect to be fully informed on the scientific aspects and probable practical consequences of their proposals. It should be unnecessary to stress the importance of that sequence and devolution: without it, there is every probability that the remaining natural resources will suffer the deterioration that inevitably follows incorrect exploitation, such as has already occurred in many areas of East Africa.

SECTIONAL REPORTS

Plant Pathology

STAFF

H. H. Storey ..... *Deputy Director*
F. M. L. Sheffield ..... *Plant Pathologist*
D. Rudd Jones ..... *Plant Pathologist*
A. K. Ryland ..... *Scientific Assistant*
V. F. Eastop ..... *Colonial Research Fellow*

The work of this Section has continued generally on the lines set out in the 1951 Report. Cassava breeding, however, has now passed into the hands of the Section of Plant Breeding and Genetics, which reports on progress elsewhere. Dr. Rudd Jones departed on leave in the middle of the year, since when research on forest pathology has remained in abeyance. Groundnut rosette studies have occupied most of Mrs. Ryland's time. Dr. Sheffield has continued work on virus diseases of sweet potatoes. Preliminary work has been started on the rust disease of maize, caused by the fungus *Puccinia polysora* Underw.

By arrangement with the Colonial Office, laboratory space has been made available to Mr. Eastop, who has been awarded a Colonial Research Fellowship for studies on the taxonomy and biology of East African aphids. His specialist knowledge will greatly assist virus research as well as economic entomology generally.

Collaboration with the Overseas Food Corporation has been made closer by an arrangement whereby E.A.A.F.R.O. exerts general

scientific supervision over the work of certain O.F.C. research officers. A report of Dr. Evans' investigations of groundnut rosette will be found in a later section of this Annual Report.

Re-establishment of research at Muguga after the move from Amani took longer than could have been expected. In particular the management of the new experimental glasshouses at Muguga, to give satisfactory growth of plants such as groundnuts and sweet potatoes, raised a number of problems that were only solved after a considerable period of trials during the early part of the year. We are now satisfied that the small, aluminium-framed houses will serve our purposes well, particularly when the installation of electric power now in progress has been completed.

Virus Diseases of Groundnuts

H. H. Storey and A. K. Ryland

During 1953 we plan to wind up the research on the relation that exists between the rosette virus, the groundnut plant and the vector *Aphis craccivora* Koch. When our work started nothing was known of this, except the simple fact that this aphis could transmit the virus. We have studied the process of transmission from many aspects and now have a fairly clear understanding of the conditions that determine transmission. On the whole it can be said that the virus-insect relationship conforms to the pattern encountered in many other plant viruses and nothing new of fundamental scientific importance has emerged from our work. Its practical usefulness has lain in establishing the facts concerning the transmission process. As it has turned out, the conjectures that could have been made at the start on analogy with other plant viruses would generally have not been far wide of the mark; but with a disease of so great economic importance as groundnut rosette there was every justification for the effort devoted to acquiring exact knowledge. We plan during 1953 to prepare papers for publication on these studies.

An important part of our work since it was restarted at Muguga has been to complete studies on the form of the disease known as "mosaic rosette," to which reference was made in our 1951 Report. In plants so affected the leaflets show only limited parts that are bright yellow, as compared with normal rosette, where the whole of each leaflet is yellow. In mosaic rosette the parts of the leaflet between these yellow, chlorotic areas show a faint mottle, readily seen in glasshouse plants but often masked in the field. By grafting an affected leaf to a healthy plant the general type of mosaic rosette is usually transmitted; but if leaves are selected as showing the smallest chlorotic areas it is possible in a few passages to eliminate completely the "factor" causing chlorosis. The result is a plant showing only mottle uniformly over its leaves; and this mottle can be transmitted on in series, by grafting or by *Aphis craccivora,* normally without change, although sometimes flecks of chlorosis may appear.

Our evidence shows that these mottled plants are immune from normal rosette, whether the virus of the latter is transmitted to them

by aphids or by grafting. We seem therefore to have an example of a phenomenon that has not infrequently been recorded in the plant-virus literature. We may suppose that in the field "the rosette virus" is not a single entity but a number of closely related strains, of which the normal rosette represents the symptom of a severe strain near to one extreme, and mottle that of a mild strain near to the other extreme. Prior occupation of the plant by one strain of the virus is effective in excluding the other, and affords the immunity to which we have referred. The observed mosaic rosette is supposed, on this hypothesis, to be the consequence of partial occupation of the plant by each of two or more virus strains.

In the course of our work we have encountered two other types of leaf mottle, not readily distinguished by inspection from the one considered above, which are transmissible by grafting and so reasonably attributable to viruses, but are not transmitted by *Aphis craccivora*. Our experiments have shown that one of these viruses does not protect a plant from the rosette virus, although there is some evidence of an interaction between them, since the doubly-infected plants show symptoms differing from those of either virus singly.

Attempts to transmit the rosette virus to other species of leguminous plants have all failed. Most of those tested have been wild species occurring at Nachingwea, Tanganyika, and found by Dr. Evans to act as hosts of *Aphis craccivora*. Although his investigations have shown that the aphis may breed on some wild plants, there is still no evidence that these plants can act as sources of the rosette virus. Thus we still know of no way in which the rosette virus is carried over from one groundnut crop to the next, except the self-sown groundnuts that are known to survive over the dry season.

Our collection of wild *Arachis* species has been augmented by a consignment of four species from the Division of Plant Exploration and Introduction of the U.S. Department of Agriculture. These, and other species previously imported, are under test for immunity from the rosette virus. As has been explained in earlier reports, the importance of these species lies in the possibility that immunity from rosette might be transmitted from them to groundnuts. The genetical studies are being undertaken by the Section of Plant Breeding and Genetics.

Sweet Potato Diseases

F. M. L. Sheffield

Mosaic-type Diseases

In my report for 1951 were described a number of symptoms on sweet potato (*Ipomoea batatas* Lam.) suggestive of virus infection. These included vein-clearing, mosaic patterns, necrotic patches, bronze mottling of older leaves, toughening of the leaves, leaf distortion, back-rolling of the margins and general stunting, together with shortened internodes and reduction in leaf size, sometimes even to a strap-shape. I have now shown beyond all reasonable doubt that

the majority of such symptoms are due to virus infection. Exceptions are few. One form of leaf distortion, which occurred in a seedling, and one of variegation, found in the field, are not transmissible by grafting and are presumably of genetic origin. A leaf-rolling symptom is also not transmissible and may be due to physiological causes, although all attempts to reproduce it experimentally have failed.

In 1951, visits to Uganda, Belgian Congo and Ruanda-Urundi had shown that the mosaic-type diseases spread more rapidly at medium altitudes than at high, and that at low altitudes no spread at all occurred. Further tours in Kenya and Tanganyika showed nothing to contradict this observation, although the critical altitudes might vary from place to place and the total amount of disease encountered was much less than further West. Virus disease was, however, always present in small amounts ready to act as a focus of infection should the conditions in any season happen to favour the vector. It must, therefore, be regarded as a potential danger over almost the whole of East Africa.

Some twenty-five specimens, which together showed all the symptoms mentioned above, but each of which differed in some way from all the others, were collected in various parts of the three East African Territories and brought to Muguga for study.

Many were on different varieties. It has now been shown that different sweet potato varieties may produce widely different symptoms when infected with the same virus. Growing conditions also may affect symptom expression to some extent.

The twenty-five diseases brought from the field are now being compared on a standard set of sweet potato varieties. Many that appeared dissimilar in the field have now been shown to be identical. There is some evidence, however, that all are not identical; but whether the different forms constitute different viruses or are merely strains of a single virus, no attempt has yet been made to determine.

Detailed anatomical and cytological examinations have been made of all the specimens mentioned and no abnormalities have been found. Nor has anything comparable to the internal cork of sweet-potato roots, described from the United States of America, been seen.

All attempts to transmit a disease mechanically have failed, although several methods (e.g. using abrasives, raising the pH of the expressed juice, using previously etiolated plants, etc.) have been tried.

Search for insect vectors has only recently started and so far has met with no success. This work will be more vigorously pursued when the various viruses have been identified.

Virus-free Stock

When working with virus-diseases, it is usual to use young seedlings as healthy stocks for experimental purposes, for only very few viruses are transmitted through the seeds of their hosts. When dealing with a hybrid crop, uniform experimental material can be

obtained only by vegetative reproduction; and if this has been collected as such in the field, it is impossible to be certain that it does not carry a latent virus. In order to provide stocks of uniform, healthy material for glasshouse experiments, some 48 seedlings from ten different maternal parents were raised; after various tests, four of these have been selected and are being multiplied vegetatively for future work.

Insect Diseases

The hairy form mentioned in my 1951 report has now been shown to be due to a mite and work on it continues.

During February, 1952, on the coastal plain near Tanga and Mombasa, it was noticed that great damage was being done by a thrips which removes the cuticle near the veins and causes distortion of the leaves and general stunting.

Forest Pathology

D. Rudd Jones

During the first six months of the year, research was continued on Canker disease of Cypresses and field studies were made on *Armillaria* root-rot. In June, the laboratory at the River Research and Development Centre was closed down. Dr. Rudd Jones went on home leave in July, proceeding to Canada in October, where he has been awarded a Postdoctorate Fellowship by the National Research Council to work at the Prairie Regional Laboratory in Saskatoon.

Canker Disease of Cypresses Caused by Monochaetia unicornis

A further collection of the fungus was made from *Juniperus procera* (Report, 1951, page 32) after a prolonged search in the main areas where this species occurs naturally. The conidia were similar in appearance and size to those of Strain D, but no culture could be established as they were not viable and diseased tissue failed to produce a lesion when inoculated into young trees. Tests on the viability of conidia have shown that germination in Strain D falls to less than five per cent after five months storage in the laboratory. The ascospores of a number of collections retained their viability for longer periods than the corresponding conidia.

In *Cupressus lusitanica* two to three years old, inoculated under standard conditions, the rate of extension was not limited in the older trees, although under natural conditions they are less likely to become infected because the cork cells prevent successful infection by conidia in the absence of a wound.

Resistance and Suceptibility of Cupressus species

Repetition of delayed inoculation experiments at Hombe (Report, 1951, page 33) in the dry season, confirmed that *C. macrocarpa* is the most susceptible species although the initial extension of the canker was most rapid in *C. benthami.* Long-term inoculation experiments at Chehe have given similar results. Half-acre plots (340 trees) of

the five *Cupressus* species were inoculated in June, 1951. When measured in September, 1951, the average size of cankers was largest in *C. benthami*, but by January, 1952, it was largest in *C. macrocarpa* and more cankers were still active than in any of the other species. The percentage of cankers remaining active seven months after inoculation at Chehe was:—

C. macrocarpa	*C. lusitanica*	*C. arizonica*	*C. benthami*	*C. torulosa*
63.2	20.6	11.1	6.0	0.6

These experiments have shown that resistance and susceptibility are bound up with the host reaction, presumably in the formation of a wound periderm effective in checking the spread of the pathogen. The initial extension of cankers is most rapid in the fastest-growing trees irrespective of host reaction.

Investigations on Monochaetia unicornis in Culture

Little difference in the size of acervuli produced on twig cultures was observed between collections of Strains A and D, but those of Strain B collections were all much larger. The length, breadth and seta length of conidia have been recorded for all collections and the data are being analysed. Further studies with Strain B have shown higher mutation rates and greater variation in the collections of this strain than in those of Strains A and D.

Experiments on the mycelial growth of the three strains at varying relative humidities were carried out, using agar media over sulphuric acid mixtures. Preliminary results have shown that the growth of all strains is limited in a saturated atmosphere, the optimal relative humidities for the growth of Strains B and D being lower than for Strain A. This work is being continued in Canada using liquid and solid media incorporating various sugars and salts. The formation of conidia and ascospores in culture is also being studied.

Armillaria Root-rot

Recording of sample plots has continued. Examination of the root systems of heavily-infected *Pinus radiata* trees revealed large numbers of rhizomorphs. A long dry spell following good rainfall resulted in a large number of trees being killed in diseased plantations and similar records were obtained in the dry year of 1949.

Other Tree Diseases

Further isolations of heart-rot fungi from Cypresses have been made. *Polystictus versicolor* was found causing a heart-rot of *Eucalyptus* sp. at Mt. Blackett in Kenya.

A *Diplodia* sp. was isolated from necrotic spots on needles of *Pinus patula* from Mufindi, Tanganyika.

A serious disease of *Eucalyptus maideni* at Mbeya, Tanganyika, apparently caused by a root pathogen, has been investigated.

Rust Disease of Maize

H. H. Storey and A. K. Ryland

During 1952 this disease, caused by *Puccinia polysora* Underw., was recorded for the first time in all four territories of East Africa. It has long been known in the Central American region, where it appears never to have excited concern; but its appearance in 1949 in West Africa was followed by widespread outbreaks and severe loss of crops.

The Secretary for Agricultural and Forestry Research for West Africa had issued warnings concerning this disease in 1951; and the East African Specialist Committee on Plant Breeding had considered in November, 1951, what steps should be taken to prepare for the invasion which appeared to be inevitable. In order to determine whether any resistance to the fungus existed in the types of maize grown in East Africa at present, the plant breeders of the Kenya and Uganda Departments sent a considerable collection for test at Ibadan, Nigeria. The officer in charge of the work here reported that, on their behaviour in the 1952 tests, East African maizes showed no resistance whatever to the West African rust.

With the appearance of the disease in East Africa the need for action became more urgent if the disease were going to prove as devastating to the maize crop as reports showed it to be in West Africa. The Committee on Plant Breeding reconsidered research policy and recommended that a breeding policy should be undertaken to secure maize types resistant to the rust and suited to the areas where it was likely to be serious. It was argued that since the disease did little damage in its home in Central America it was likely that natural selection had produced maize types there that were resistant; and that maize seed should be imported from this region in the hope that, even if no types proved to be of direct use in cultivation, at least resistant genes might be obtained that could be transferred by breeding to locally-adapted types.

Following the recommendations of this Committee, a plan for co-operative research between E.A.A.F.R.O. and the Kenya Department of Agriculture has been prepared. E.A.A.F.R.O's part in it will be the introduction of exotic maize varieties, their testing for resistance by intensive methods in the glasshouses at Muguga and crossing of the more resistant ones with East African types. In preparation for this, the Plant Pathology Section during the last two months of the year started work on developing techniques for experimental infection. In this it has received most valuable help from Dr. Nattrass of the Kenya Department of Agriculture, who had been responsible for the greater part of the diagnostic work on which our present knowledge of the disease in East Africa is based.

When it was found that *Puccinia polysora* was widespread in parts of Uganda, the Department of Agriculture in this country also agreed to co-operate in the field testing and breeding programme.

By the end of the year we had secured experimental infections of maize with rust spores from three separate localities and a standard technique for the glasshouse tests was beginning to take shape.

Taxonomy and Biology of Aphids

V. F. Eastop

During the two months since my arrival at Muguga I have spent most of my time collecting aphids and setting up cultures of those species found only in small quantities. About 40 species have been found, including a number of apparently undescribed ones. Day collecting trips away from this station have been made in several parts of Kenya, and about a week was spent at Kawanda, Uganda. Two aphids of considerable economic importance in other parts of the world, not previously recorded from East Africa, have been found; they are *Myzus ornatus* Laing, a polyphagous species, and *Pentalonia nigronervosa* Coquerel from bananas.

Aphid traps have been operated at Muguga from the middle of December, to study the seasonal and diurnal variation of aphid flight. Shallow water-filled trays were used, painted yellow, since this colour has been found to attract the insects. The thrips from the trays have also been retained and it is hoped to identify them later.

Some host-plant transference experiments have been done with aphids that appeared to be polyphagous in the field; and in conjunction with Mrs. Ryland some attempts have been made to transmit rosette of groundnuts with aphids other than *Aphis craccivora*.

Plant Breeding and Genetics

Staff

L. R. Doughty ..... *Plant Breeder-in-Charge*
D. J. Jennings ..... *Plant Breeder*
D. W. Gourlay ..... *Experimentalist*
T. Graham ..... *Field Assistant*

Cassava Breeding

L. R. Doughty, D. W. Gourlay, D. L. Jennings

Breeding for the production of cassava varieties resistant to two virus diseases has continued. This work is centred on Amani, where two officers have been stationed through 1952, with outstations at the Sisal Experiment Station, Ngomeni, at Kizugu and at Kwamkoro. Progress has been made in evaluating the very many hybrid clones that have resulted from previous years' crossings. The Amani varieties are now widely distributed in East African territories, where they are under trial at Departmental experiment stations and on private estates. In some areas these varieties have come into general cultivation and there are reports of large improvements in yields.

Breeding

No crossing was done during the year as the new programme was not ready in time for the main flowering season. Some 2,500 seedlings were obtained from the crosses made in 1950-51. These have grown strongly in the nursery and have produced an adequate supply of cuttings for planting in elimination and resistance trials.

Field Work

One hundred and seventy clones from the 1949-series of crosses were planted in an elimination trial in November, 1951, and this trial was harvested in August. Fifty-seven of these clones have been retained for further trial.

During October and November the remaining sixty-two clones of the 1949-series and 2,117 of those from the 1950-series crosses were planted in elimination trials at Kizugu sub-station or the Sisal Experiment Station, Ngomeni. During this same period replicated resistance trials were planted at Ngomeni and include 262 clones. Some of the 1950-series seedlings have been included in these trials without any preliminary elimination trial. The other clones under trial are from 1949-series crosses and some undergoing a second resistance trial. A lattice trial containing twenty-five clones has been planted at Kizugu. It is to be continued for a longer period than the normal testing period, eight to nine months; and a similar trial has been planted at Gombatu Estate, Ukundu, Mombasa, where mosaic and brown streak infections are particularly severe.

An experiment is in progress in the greenhouse at Amani in which seedling clones are exposed to heavy infestation with the virus vector in the presence of infected material. It is hoped that a technique can be evolved for more intensive testing of seedlings, with a consequent reduction in the time occupied in testing new material. Promising results have been obtained with seedlings of a susceptible variety, but more information is required before the method can be put into general use.

Leaf Roll

During 1949-50 resistance trials one clone showed a peculiar type of leaf roll and it was thought that this may have been due to a new virus. Attempts to transmit the symptoms by grafting scions of the curled material on to the normal type and on to Mbarika, showed no transmission of the supposed symptoms. Seedlings obtained from isolated plants showing the leaf roll have, however, shown segregation of the leaf-roll character. Amongst thirty-two seedlings raised, nine had a much more severe leaf roll than the parental form, thirteen were typical of the parental form and ten were normal plants. It appears probable, therefore, that this is a mutant form.

Issues of Resistant Material

The first series of clones issued for trial to Departments of Agriculture in East Africa were mainly cassava varieties and intra-specific hybrids. Later interspecific hybrids and various back crosses of these with cassava were issued. Encouraging reports have been received from Uganda, Tanganyika and Zanzibar on the behaviour

of these early issues and now reports are beginning to come in of trials with the later issues. In Uganda and the Lake and Eastern Provinces of Tanganyika a good deal of material has already been issued to growers, having proved much superior to the local varieties.

A few new issues have been made during the year, but these have been restricted to areas in which brown-streak disease is known to occur. Since this disease is often difficult to diagnose in material from which cuttings are required, an attempt is being made to introduce an intermediate quarantine for material for distribution. To this end cassava is being tried at Eldoret, where conditions should be favourable for the expression of the symptoms of the disease and where there is no danger of spreading it. Most of the first clones sent up for trial have grown well from the point of view of the production of stems for cuttings. A second consignment has been planted and most of the clones appear to be established, but it still remains to be seen how productive in stems they will be.

Maize

L. R. Doughty

A new line of work has been started, a study of the technique involved in the production of relatively stable, heterozygous populations of maize for use in the native reserves. Although in the first place this is mainly concerned with the maize-growing areas of Nyanza Province, Kenya, and is being carried out in co-operation with the Department of Agriculture, it will have much wider application in the long run.

A collection of East African maize varieties has been grown at Eldoret during the past season and individual plants in each line have been selfed and the remainder open-pollinated. Arrangements have been made with the Agricultural Department for the collection of more or less random samples of maize from the various locations in Nyanza Province and also for the collection of selected cobs from good farmers in the various locations. This material and that handled in 1952 will be planted at the Eldoret sub-station of E.A.A.F.R.O., and also on a plot of land made available by the Kenya Department at Bukura in N. Nyanza. Most of the work requiring isolation will be done at Eldoret and variety trials at Bukura.

Resistance to Streak Disease

Little progress has been made with this project during the year beyond the resurrection of some of the old 1940-41 streak-resistant hybrid material from Amani and the collection of more material from the Lake Province, Tanganyika, where streak is prevalent. Some difficulty has been experienced, both at Muguga and Eldoret, in maintaining cultures of the vector, *Cicadulina*, for the extension of this work.

Resistance of *Sorghum* to *Striga hermonthica*

L. R. Doughty

The object of this project is to develop, if possible, a method for the intensive testing of varieties for resistance to this destructive

parasitic weed. A few preliminary trials have been made but there is nothing of any importance to report.

Groundnut Breeding

D. L. Jennings

Interspecific Crossing

Breeding work with *Arachis* spp. was started by this Section at Amani in March, 1952. Amongst the species that had been growing there since 1950, two varieties of *A. Diogoi* (CPI 8987 and 8988 ex Canberra) and one of *A. prostrata* (No. 2 ex Sao Paolo), were found to have fruited freely. Three other species, *A. glabrata*, *A. prostrata* (ex Kew), and *A. Diogoi var major* flower freely but have not fruited. The collection is now being grown at Amani, Kizugu and Ngomeni. Cuttings of various species have been sent to the Overseas Food Corporation at Nachingwea for field tests for disease resistance and to the Department of Agriculture, Uganda, for trial as pasture plants.

As stated in earlier reports, the purpose of studying these non-economic diploid species is to see if any carry factors for resistance to rosette, and to attempt to hybridise them with the tetraploid groundnut, *Arachis hypogaea*. Only *Arachis Diogoi* was flowering when work started early in the year; and the early attempts at hybridisation were, therefore, confined to this species. As reported earlier, this species produces only mild symptoms when infected with rosette virus, while more recent observations indicate that it is also highly resistant to, or immune from, *Cercospora* leaf-spot. Over 700 crosses were attempted, using pollen from *Arachis Diogoi* on emasculated flowers of groundnut (variety Natal Common). Although many of the plants from which pollen was collected were not setting fruit at the time, the fertility of the pollen, as shown by its capacity to germinate in sugar solution, was high. Approximately ten per cent of the flowers pollenated showed signs of a response. This response varied from the production of pegs which failed to produce a fruit to the formation of seedless fruit. In only a few cases were seed harvested and it remains to be seen whether these are in fact the result of true crosses.

The habit of *Arachis Diogoi* to bear fruit only on mature plants, which are very spreading and cumbersome for greenhouse work, has handicapped work using this species as female parent. A hundred pollinations of *Arachis Diogoi* with pollen from *Arachis hypogaea* produced no response, and, since the plants were not bearing fruit naturally, further attempts were discontinued. For the same reason attempts to intercross the diploid species, e.g. *Diogoi* and *prostrata* are not being continued at present. All attempts to induce the young *Diogoi* plants to produce seed by artificial pollination using the same and different clones of the same species have given negative results.

With the onset of the higher temperatures, *Arachis prostrata var* ex Kew came into flower and crossing of this species, which is probably immune from rosette, is being attempted. As with *Arachis*

Diogoi the pollen germinates well in sugar solution, although the flowers appear incapable of setting fruit. The success of these crosses is not yet known.

The second approach to this problem is by the use of colchicine to double the chromosome number of the diploid species and thus to facilitate their crossing with the tetraploid groundnut. Attempts to double the chromosome number of *Arachis Diogoi, Arachis prostrata,* and *Arachis glabrata* by treating the growing tips with colchicine solutions and with colchicine-agar have been made and are proceeding. Attempts to treat the seed of *Arachis Diogoi* and also to inoculate the colchicine into the plant are also being made.

Intervarietal Crosses of Arachis hypogaea

A number of crosses between the groundnut varieties, Natal Common and Mwitunde, and also with the *Nambiquarae* varieties have been made.

Selected seed from the F4 generation of the crosses made by the Pathology Section were planted at Amani in May. Plants failed to fruit, possibly because of the cold temperatures occurring at this time of year, and a further selection has now been planted at Kizugu sub-station.

General

The use of rooting hormones for the vegetative multiplication of groundnut from cuttings has been tested. Good success has been attained and it is thought that this method may have applications both as a means of increasing the supply of F2 seed and also for testing the F1 plants for reaction to virus diseases.

Crop Insecticides

STAFF

K. S. McKinlay ..... *Entomologist*

As explained in the 1951 Report the programme for that year was drawn up to cover as wide a field as possible and was largely exploratory, since it was the author's first year of work at the Cotton Research Station, Namulonge. As a result of this work it was possible to start the 1952 cotton season with a reasonable idea of the problems involved in the use of insecticides on cotton and particularly of the more fundamental and generally applicable aspects.

The application of insecticides on any large scale to control the pests of peasant-grown crops will not be practicable for several years and is hindered, not so much by the lack of knowledge, but rather by the fact that the crops are grown on small and scattered plots by peasant cultivators, for whom the use of insecticidal control will only become possible after a programme of education or a change in their methods of agriculture towards mechanisation and the growth of crops on larger units. These more applied aspects are already being investigated by the departmental entomologists concerned. Under

these conditions it was felt that the most useful work that could be done by the E.A.A.F.R.O. entomologist was the investigation of the more fundamental problems involved in the use of insecticides under tropical conditions. This work has been carried out at the Cotton Research Station, Namulonge, where all aspects of crop production by the cotton plant are being studied; and because of the economic importance of cotton the insecticide work has so far been limited to this crop. Insect pests are one of the factors which influence the yield of cotton; and it was felt that it was essential in the first place to obtain accurate knowledge of the extent to which each pest reduced the yield and exactly how this reduction was brought about. This problem can only be studied if some of the cotton can be grown without any insect attack, and for this work modern insecticides are an essential and useful tool.

In the case of cotton in Uganda, the experiments during 1951 showed that two groups of pests were capable of reducing the yield of the plant. In the earlier part of the season Cotton Lygus, *Lygus vosseleri* Popp., attack the plant, followed later in the season by several species of Bollworm, principally *Heliothis armigera* and *Earias* sp. These two groups to some extent overlap and together cover a period of some four months. It is doubtful if it would ever be economical to spray throughout the whole four-month period, and the problem is further complicated by the ability of the cotton plant to compensate in varying degrees for insect damage by forming fresh fruiting points once the pest attack has ceased. The ability to compensate is dependant upon the length of the growing season and the time and duration of the insect attack.

During 1951 a randomised block layout of 1/40th acre plots was used for field experiments; but it was found that the application of insecticides to plots of this size, whilst affording protection against bollworms, was unsatisfactory for the study of Lygus. The adults of this insect are extremely mobile, and interference between treated and untreated plots was so great that the Lygus attack on the untreated controls was reduced to almost the same level as on the treated. Thus one of the first problems during 1952 was to find an experimental layout in which insecticides could be used to protect some of the cotton whilst still providing representative untreated control plants and not using impossibly large areas of cotton. This problem has now been solved. Certain field observations during 1951 suggested that some insecticides might be repellent to *Lygus* and this was confirmed in laboratory experiments using D.D.T. and Toxaphene. A field trial during 1952 was laid out to see if this repellent effect was sufficient to protect a proportion of the plants in a cotton strip, so that by comparison the yield reduction on the untreated cotton in the field could be obtained. This method seems to have been successful, and the adult *Lygus* did not feed on the repellent-treated cotton but preferred the more attractive untreated plants all around them. This method and the experiments leading up to it will be described in detail in a paper which is being prepared. Since any bollworm larvae hatching on the treated plants are also killed, our major problem has been solved and it is now possible, by including relatively small numbers of sprayed cotton plants in any field, to obtain accurate figures for the losses due to the various insect pests, and by a study

of the crop formation on protected and unprotected plants to determine in what manner the losses are caused.

The 1/40th acre plots originally used were quite adequate for the study of the effects of insecticides upon the bollworms; and results of two years experiments on these pests are now being prepared for publication. In general the conclusions are as follows:

1. D.D.T. is probably the most effective insecticide, of those readily available and safe to use, for the control of American and spiny bollworms on cotton.

2. Difference in effectiveness of the same quantity of D.D.T. applied as a dust, a low volume or a high volume spray are probably not sufficient to prevent one using whichever method of application is the most convenient under local conditions.

Future programme

The last two years have been devoted to finding the most important problems with which we were faced and evolving suitable techniques for their study. It is now possible to go ahead in co-operation with the E.C.G.C. entomologist, on the following programme.

1. To discover the amount of crop loss caused by each pest.

2. To study the inter-relationship between the type of damage caused by the pest, its timing and duration, the manner in which the cotton plant bears its crop and the length of growing season.

It is hoped that this programme will eventually supply the knowledge necessary for making the most efficient use of insecticides to protect East African cotton crops against losses from insect pests.

Plant Physiology

STAFF

J. Glover ..... *Plant Physiologist*
C. M. D. Harrison ..... *Temporary Assistant*

Most of the year was occupied with work on Pyrethrum "bud-disease", caused by a fungus (*Ramularia bellunensis*), though the nutrition studies continued with the growth of a fodder sorghum in sand culture. As the opportunity occurred work on the preparation of the provisional maps of the reliability of rainfall was continued.

PYRETHRUM "BUD-DISEASE" STUDIES

The reason why investigation of this fungus disease of pyrethrum was included in the programme of the Plant Physiologist has been discussed in the 1951 Annual Report.

The following main studies and a number of subsidiary ones arising from them were undertaken:—

(a) To investigate the effectiveness of Bordeaux mixture in controlling the disease, even if it was applied at heavy uneconomic rates. The object of this was to make sure that the fungus could be controlled by a fungicide irrespective of cost. If it could be controlled then further work, possibly with newer fungicides, or smaller dosages, or less frequent applications of Bordeaux could be investigated by the officers of the Kenya Department of Agriculture.

(b) To study the growth of healthy and diseased buds in relation to climate. Among other things, this included comprehensive statistical analyses of past records of yield and climate obtained by the officers of the Pyrethrum Experiment Stations.

(c) To study "intra-clonal" variation in numbers of disease buds or percentage disease rate.

The results to date are as follows:—

Spraying Trials

It was apparent at an early stage that the Pyrethrum plant was difficult to wet properly with a low pressure spray of Bordeaux mixture. To get efficient penetration of the hairy bud stalks some 0.4% of a liquid detergent was added to the spray. I am indebted to Dr. Nattrass, Senior Plant Pathologist of the Kenya Department of Agriculture, for the information that this detergent was not fungicidal at the concentration used.

Spraying was started in the dry season when the clumps carried few or no flowering stalks. It was applied every 10 days throughout the year. The rate of application was 200 gallons/acre (10,500 plants) when the clumps were small and this was increased to twice the rate as the plants grew larger. Throughout the experiment the healthy and diseased buds produced by each plant were measured weekly.

The massive doses of Bordeaux applied at such short intervals had no detrimental effect on bud production. The average weekly total number of buds harvested per plant (i.e., healthy flowers + diseased buds) was similar in both the sprayed and unsprayed series during the 5-month season preceding maximum production. During, and immediately after, the period of maximum production (2 months) the sprayed plants had a significantly higher total bud production per plant than the unsprayed. This may have been due to stimulation by copper but, as the season was fairly dry, it may also have been due to the water in the spray. The only damaging effect of Bordeaux mixture was shown by the open flowers, whose ray florets were scorched by drops of spray.

The effect of the spray in controlling the disease was most striking. During a particularly severe attack, lasting several weeks, the unsprayed plants had a disease rate of 18% while the sprayed plants had 2% or less. Throughout an eight-month season the disease

rate in the sprayed plants was statistically very significantly lower than in those which were untreated.

There seems to be little doubt therefore that Bordeaux mixture applied in massive doses can control the disease.

Under heavy and persistent rain the spray containing the detergent sometimes seemed to be washed off more readily than that which had none. Work will have to be done on the use of "stickers" as well as "spreaders".

Total bud production in relation to chilling

It was apparent at an early stage in the investigation of past records of climate and yield that the number of buds developing on the plant at any one time depended on the amount of chilling that the plant received some weeks earlier. For example, weekly counts at the Molo Experiment Station in 1950 showed that during the seven-month harvest period the number of flowers plus diseased buds harvested (i.e., total number of buds stimulated earlier) depended on the number of degree hours spent by the plant below 60°F. some 13 weeks earlier. The regression of yield (numbers of flowers) on temperature was significant to much more than 1,000: 1. Once this effect of chilling was recognised it was possible to show that the period of maximum production in East Africa (mainly Sept.-Nov.) followed the cold season (mainly June-Aug.). This explains a recognised difference in the apparent behaviour of the plant in Kenya and in Southern Tanganyika although in both areas it flowers profusely at similar times. In the former areas the main flush follows the rainy season; in the latter it follows the dry season. Both, however, have a common cold season.

The prolonged flowering season of Pyrethrum in East Africa contrasts markedly with the reported short seasons in Yugoslavia and Japan, the other main producing areas. The difference seems to be mainly in the degree of chilling that the plants receive. In the latter regions the severe winter chilling during dormancy seems to be sufficient to stimulate most of the buds so that they all tend to develop together with the onset of warmer weather. In East Africa the plant is never completely dormant though it passes through a "dormant" period in the hot season which resembles to some extent *aestivation* in a zoological sense. With the onset of cooler weather a few buds are stimulated by slight temporary spells of cold and these of course develop rapidly because of succeeding high day temperatures. Further increase in chilling as the cold season approaches stimulates more buds to develop and the effect reaches its peak at the height of the cold season, thus giving a peak "flush" of flowers some weeks later. Intermediate minor "flushes" can be related to intermediate temporary increases in chilling.

This chilling stimulus is most marked in the main growing regions. At high altitudes, however, it is apparently somewhat concealed behind a development effect caused by warmth. There the chilling is adequate for bud stimulation but the warmth necessary for the normal rapid development of the stimulated buds may be lacking except in temporary bursts. Yield in these cold regions therefore

seems to be associated with heat as well as cold. This latter observation has proved difficult to check, for the main Experiment Stations are in the main growing areas and few growers at high altitudes keep temperature records.

As a further test of the effect of chilling, plants were exposed to temperatures of 60°F. plus or minus 1°F. for 10 days and compared with similar plants in the open which had an average of 9 hours per day spent at or below 60°F. over the same period. All were then exposed, side by side, in the open, to the normal climate of the field. The treated plants at the end of three months had an average of 22 mature flowers per plant as compared with an average of one in the untreated plants. At the end of five months the treated plants had each produced an average of 96 mature flowers while the untreated ones had each produced only 15.

As a check on the chilling effect it was possible to investigate the records of a "cutting-back" trial at Molo Experiment Station in 1949. It is a common practice among growers to cut back old stalks and any new growth, down to clump level, in an effort to improve yield, clean the fields and make easier the picking of new flowers and to attempt to displace the "flush" in time so that the worst of a "bud-disease" attack can be avoided. If, however, the chilling stimulus is an over-riding factor in bud-production then the "flush" could not be displaced in time and any attempt to tamper with it would result in loss of yield. This showed up clearly in the experiment. Control plants left uncut from the previous year were compared with plants cut-back on the first of each month throughout the year. Those cut-back during the hot season when the clump was "dormant" gave similar yields throughout the flowering season to those of the control plants. The intermediate and main "flushes" occurred at similar times. Those cut-back in succeeding months also gave similar yields and times of flowering except that each lost in yield between the time of cutting back and the restoration of normal production. If they were cut-back early in the cold season the loss was slight. The loss increased as cutting-back extended into the cold months and was greatest when it took place after the cold season. In the latter case cutting-back removed most of the buds just developing after the main stimulus received in the cold season. No matter when the plant was cut-back the plants produced the maximum and intermediate flushes at the same time of year except in those cases where cutting-back was so late that it removed the buds which would have produced the flush.

The practical applications of this study are obvious. "Cutting-back" does not alter the time of "flush" so that the plants can escape attack by "bud-disease" and it may even cause loss in yield if done too late in the year. It apparently does not increase yield, for even those plants cut-back early in the year have similar yields to the control plants and those cut-back later have less. It may, however, be justified on the grounds that it makes picking easier in the forthcoming season or, if the old stalks carry the resting stage of the fungus, as a sanitary measure. If, therefore, it is economic, it should be carried out as soon as is reasonably possible in the "dormant" period.

"Intra-clonal variation" in disease bud production

The officers in charge of the Pyrethrum Experiment Stations have directed my attention to the well-known phenomenon that individual plants in clonal material vary widely in the number of diseased buds that they produce throughout the season. An investigation of two years records at Molo and of eight months records at this Station showed that the number of diseased buds produced by the plant depended on its size. The total number of diseased buds harvested throughout the season increased logarithmically with increase in the total number of buds produced by the plants and the latter was directly related to clump circumference at nine inches above the ground. In other words, the bigger the plant the more diseased buds it produced.

"Intra-clonal variation" in disease bud production was therefore largely reduced to variation in the size of the plants. A closer examination of the detailed records kept at this Station shows that the variation is probably due to variation in quality of material used for planting. In order to establish the experimental plots quickly we followed the normal practice of dividing old clumps and planting the resulting "splits". These although they appeared of reasonably similar size at planting cannot have been identical. Some grew quickly, others slowly. Some provided a continuous harvest from the end of the hot season and at the other extreme others only came into flower just before the period of maximum production. Extremes of the range of production were from 15 to 700 flowers per plant.

If the clonal planting material used at this Station is indeed similar to that used by the farmer then an investigation of the quality of planting material is likely to lead to some useful practical results. The farmer may be losing much of his potential yield in the first year because of the variable quality of the "splits". It is possible too that the plants which made poor growth in the first year may do likewise in the second. This is being kept under observation.

An interesting confirmation of the chilling effect on bud production was also observed in this investigation. Those plants which grew badly also reached a peak in flower production simultaneously with those which grew well and thereafter both declined in yield at the same time.

Disease-bud production in relation to climate

As mentioned in last year's Annual Report, there was some suggestive but inadequate evidence that the plant is infected some considerable time before microscopic symptoms of the disease appear.

A search for the climatic factors concerned seemed to show that cold and dampness were connected with diseased-bud production. For example, statistical analyses of data from Molo Experiment Station shows that the actual number of diseased buds harvested weekly in 1950 was directly connected with the number of degree-hours spent by the plants below 50°F. some 13 weeks earlier. Records of the 1949 harvest from the same place showed that the actual number of diseased buds harvested every 10 days were inversely related to the

10 day mean minimum temperatures some 14 weeks earlier: i.e., as the mean minimum temperature falls the number of disease-buds increases. The connection in both cases seemed to be through the wetness of air, for cold in the growing regions entails dampness of air. This was to some extent confirmed by showing that, for 1949 at least, the disease-bud production was linked with wetness of air some 3-4 months earlier. The connection was apparently not associated with chilling response, for disease-bud production was not related to total bud production.

The above results were based on records from whole plots, not from individual plants. They will have to be re-examined in the light of the results from the study of variation reported above, for it is probable that only a few very active plants supplied most of the disease buds in the plot totals, particularly during the early part of the season.

A long series of records throughout the year have shown that the relative humidity of the air within the clump is higher than that of the air surrounding the clump except during prolonged dry spells. This is most marked when rain falls during the night. For example, on one day when an inch of rain fell during the previous day, the last shower of which stopped at 1.15 a.m., the air around the clump was at 85% R.H. at 8 a.m. and it fell steadily to about 70% R.H. by 12 midday. During the same period, the air in the clump remained at saturation (100% R.H.) until 9.30 a.m. and had reached only 96% R.H. by midday. As the morning was bright and sunny and a light breeze was blowing over the plants, it is obvious that the clump dries slowly and that humidities measured in a screen do not compare with those in the plant.

A large box in which humidities can be controlled in the region of 96-100% R.H. and which can be kept at a temperature of 59°F. has been built for testing plant response to deliberate infection by spores of the disease.

The nutrition of a fodder sorghum

The balance of nutrition between nitrogen and phosphorus was shown to be important in the growth of a fodder sorghum. The results of the measurements so far completed are similar to those reported for maize in previous years.

Maps of the reliability of rainfall

Very little time could be devoted to these maps this year. The draft maps were in constant demand by ecologists and agriculturists. It has been possible to show that the distribution of certain plants and animals agrees well with regions of particular rainfall reliability, a feature which cannot readily be detected in existing maps delineating isohyets of average rainfall. It is hoped to publish these maps during 1953.

Clove Research Scheme, Zanzibar

STAFF

F. J. Nutman (1) ..... *Director*
F. M. Roberts (2) ..... *Specialist Officer*
M. J. Way (2) ..... *Entomologist until* 14/7/52
T. E. C. Robins (1) ..... *Field Assistant*

(1) Seconded from E.A.A.F.R.O.

(2) Seconded from Rothamsted Experimental Station.

Note.—This report is the last which will be submitted, since the Scheme will close down at the end of the year, after almost exactly five years of work. During this period the Dieback problem has been completely solved, the Sudden-death investigations brought to a point where technological studies on control methods can begin, and a connection demonstrated between the Sudden-death of mature trees and the slow decline of young ones. In addition the cause of the premature nut-fall and gummosis of coconuts has been discovered, the complicated inter-relationships between the various plants and insects concerned investigated and suggestions for control methods put forward. During the lifetime of the Scheme, a total of 20 papers has been written; these are either published or are in the press. The titles will be found on pp. 17 to 22 under the following names: May, Nutman, Robb, Sheffield, Way.

During 1952 the plantation-scale experiments, started in the previous year, to eliminate *Cryptosporella eugeniae*, the cause of Dieback disease of clove trees, from a typical group of trees, has shown that this can successfully be done. There is now a marked difference between treated and control trees in the same plantation, and a striking difference between this and other typical Zanzibar plantations. A few modifications in methods have been introduced, mainly aimed at preventing the occasional re-infections which occur in trunk excavations, and at reducing the costs of treatment.

The main emphasis during the year has been on trying to obtain unequivocal experimental proof that *Valsa eugeniae*, invariably associated with clove trees which have died of Sudden-death, is the cause of the disease. Certain evidence can be advanced to show that *Valsa* can act, sometimes with great rapidity, as a wound pathogen of both roots and branches. Two major experiments have been laid out in an attempt to reproduce what is thought to be the natural method of infection by *Valsa* of clove tree roots, i.e., ascospores discharged during wet weather and subsequently washed into the soil. In one of these, in which a group of 18 trees is involved, invasion of the finer roots has been demonstrated, and the fungus has, in some cases, invaded roots of up to 1.5in. in diameter. Preparation of the roots for this experiment probably damaged them to some extent, and this may have hastened the process of invasion. In the second experiment, in which roots have not been damaged, but where heavy doses of inoculum have continuously been applied, no excavations of roots for examination have yet been made. Full details of these and all the other long-term experiments will be left with the Department of Agriculture.

No information is yet available as to the length of time between first infection and death, but it is thought that this is likely to be measured in years rather than in months.

The slow degeneration of young clove trees, now associated by us with replanting in old Sudden-death areas, and described as Slow Decline, has been brought into the Sudden-death picture by the demonstration that *Valsa* can be isolated in pure culture from the roots of such trees, or demonstrated in them after the death of the tree. This disease becomes apparent when the major part of the root systems of affected trees are already in an advanced stage of decay, and it is thought to be an expression of the gradual break-down in the juvenile resistance of young plants to infection.

Proposals for control experiments in Pemba, and for the re-establishment of healthy clove plants in the devastated areas of Zanzibar Island have been put forward to the Department of Agriculture.

The entomological work begun by Mr. Way was continued by him at Rothamsted by the courtesy of the Director, and four papers are now ready for publication. One aspect of this work can confidently be expected very greatly to increase coconut yields in East Africa. During 1952 laboratory and other facilities were afforded to Dr. Vanderplank, appointed by the Zanzibar Government to continue research on *Theraptus*. The Director of Clove Research was scientifically responsible for this work up to the end of 1952.

Emphasis has been laid on control methods, and progress has been made. Dr. Vanderplank's full report will appear in the Annual Report of the Department of Agriculture.

Forestry

STAFF

A. L. Griffith ..... *Silviculturist*
B. E. St. L. Stuart ..... *Assistant Silviculturist*
W. B. May ..... *Horticulturist*

General.—The year has been one of general consolidation and development of forest experiments in Muguga Estate. The Assistant Silviculturist (Mr. Stuart) arrived in March.

Information.—Work on the collection of information in the Forest Bureau continued. In the two years it has been functioning 1,184 specific files and 395 general files have been opened, and already much use is being made of them. Information is already going out as well as coming in, as is shown by the fact that during the year 93 requests for information were answered by the Bureau, and of these 37 were from farmers, or the general public.

Work on the compilation of an East African Forest Bibliography is almost complete, and it is hoped that it will be published early in 1953.

Nursery Work.—It is unfortunate that this report has to be for the calendar year, whereas the experimental work year really ends in April with the beginning of the long rains. Many experiments are in progress in the nursery, but they have not yet got to the stage where definite results are available. Several soil experiments are in progress chiefly with pines such as *P. radiata, P. patula, P. engelmanii,* and *P. montezumae.* These experiments are on the use of various quantities of pine soil in the beds and boxes, the use of various quantities of several fertilisers with and without a pH variation superimposed, the effect on resulting growth of the use of 8 different soil mixtures, and numerous small cultivation and watering experiments to endeavour to improve nursery technique. In general, experimental work in the past 2 years has led to a great improvement in the nursery technique of our exotic softwoods, as can be seen from our own nursery and many nurseries of the territories. We are definitely producing better plants in a shorter time as a result of this work.

Experiments on the Swaziland technique of root pruning nursery beds with piano wire have been continued. Edging the beds with rough dressed local stone or with wattle poles or with gas piping failed, but cedar poles dressed on the under side are successful so far. It is of interest that in Kenya, bamboo has been successfully used, and that in Sukumuland (Tanganyika) old railway lines are promising. It is essential to use a cheap local material.

Grafting experiments with pines and cypresses for seed orchard production have been started and appear promising.

A block of 10 closed frames, 5 of which are equipped with an underneath controlled watering device has been built for further experiments on vegetative propagation.

Nursery Course.—A course to discuss the basic principles of nursery practice was held in November. It was attended by 17 forest officers and foresters from the three mainland territories and also from Zanzibar. The course was both practical and theoretical and included talks by various specialists of E.A.A.F.R.O. Visits were made to nurseries and plantations of Kenya.

Arboretum.—The object of the arboretum is to raise small plantations of a large number of our exotic softwoods. A start was made this year by the raising of such plots for 24 species chiefly pines and cypresses. All plots are successful so far in spite of trouble with buck and ant-bear. A further 50 plots will be raised in the 1953 long rains.

This is a most important project as we feel that many of the species already introduced into E. Africa have not necessarily had a fair trial, and it is by no means certain that the most suitable species or strains have yet been introduced.

In 18 of the plots in the arboretum a series of plants are being measured every week to give us data of when the different species grow, how much they grow, and to what meteorological conditions the growth can be correlated. It will of course be 4 or 5 years before

we get a true growth period picture, but in the last year the main growth started in September and October. This of course coincided with higher day temperatures and some sunny weather after the rainy period, which is usually immediately followed by a season of low temperatures and mist.

Short term and long term planting out experiments.—We have now raised sufficient stock for a start to be made in the 1953 long rains in this subject for our exotic softwoods.

Enumerations.—Work on the study of enumerations to find out the most suitable, economical and efficient methods of stocktaking in our forests was continued. Several research articles were published in the *Empire Forestry Review* and the subject was also discussed at the Commonwealth Forestry Conference in Canada. It is noteworthy that in this work we are all apparently coming to a general conclusion that an enumeration of from 1 to 5% is necessary to give us a reliable picture of the forests.

Conferences.—At the end of 1951 the Silviculturist attended the forest conference at Abidjan on the French Ivory Coast. At this conference there were some 50 delegates from all the countries in Africa south of the Sahara. It was a most useful meeting from the point of view of formulating a common forest policy and terminology for the many countries and languages represented. It also resulted in useful discussions on the different ways in which similar forest problems were being tackled in the different parts of Africa.

The Silviculturist was also a delegate to the 6th British Commonwealth Forestry Conference in Canada in August and September 1952. This conference was attended by some 60 delegates from all parts of the Commonwealth and Empire, and observers from the U.S.A. and F.A.O. It was particularly important in the exchange of ideas and methods from all over the world, many of which are directly applicable to East Africa. Examples are so widely different as one-man portable chain saws, herbicides and arboricides for keeping electric transmission lines clear of vegetation, new methods of aerial photography and enumerations, etc.

At the conclusion of the Canadian Conference, the Silviculturist visited Oxford, where he gave a number of lectures to forest students and post graduates and budding botanists and ecologists, on East African forest problems. He also visited the Commonwealth Forest Bureau (Information).

Muguga Estate.—We have had great difficulty with the Estate during the year, which has been one of intense development. Labour was very scarce during the long rains and this seriously hampered our programme. Although the situation was much better during the second half of the year, the standard of work done remained deplorably low. We have been unable to get literate responsible Africans for supervision of works.

Theft has been our big problem, and continues to be so. Until we have the powers of forest officers under the Forest Ordinance this will

be almost impossible to deal with. We had considerable trouble in March and also in September with forest fires, some of which were deliberate.

Fair progress has been made with thinning the crops which exist on the estate, although we shall not be able to clear off the arrears for some time. The estate boundary now has a wire fence and a 20 ft. cleared line. This has greatly helped our protection problem.

With construction and development going ahead so fast one of the problems constantly before us is the supply of fuel for our gas plant, for the laboratories, and for the residents of the Estate for their cooking and heating. We have to think of the future, because it takes some 8 to 10 years to grow fuel. This means that all areas in the estate must be productive if not being used for experimental purposes. During the year some 20 acres were planted with *Eucalyptus saligna,* and this area had a somewhat chequered career. Some 10% of the plants were pulled up and stolen after planting, and many others were browsed by game. An acute shortage of labour hampered weeding and tending in the first few months, but in spite of all these difficulties, results may be said to be fair.

A sample plot was laid out in 36-year-old *Eucalyptus saligna* in conjunction with the Kenya forest department. This sample plot is intended as a demonstration plot for visitors as well as for the collection of crop data.

The site for the E.A. Plant Quarantine Station was negotiated with the Kenya Forest Department and cleared and stumped.

Forest Entomology

STAFF

J. C. M. Gardner ..... *Forest Entomologist*

Mr. Gardner transferred from the Kenya Forest Department in October, 1951, and moved to Muguga in March, 1952, taking his staff, one African youth, with him.

Objects of research come under two heads: (a) Survey of Forest Insects and (b) Investigations into insects of special importance. Information so far recorded may be regarded as satisfactory.

Co-operation with the Three Territories

Kenya.—A forest entomologist, three entomological foresters and four African rangers are likely to be appointed in the near future. One forester (Mr. J. O. Evans) has already been working since March under the guidance of Mr. Gardner, at a field station opened at Londiani.

Uganda.—Two African rangers were sent by the Uganda Forest Department, in January, 1952, for training by the forest entomologist and have since been engaged on forest insect survey work in Uganda. This arrangement is proving very satisfactory and it seems probable that these men may be able to carry out specific experiments later on.

Tanganyika.—No forest insect staff has been appointed.

Survey of Forest Insects

The aim is to accumulate information on any insects associated with forests and forest products whether of apparent economic importance or not; certain species are noted for further investigation when opportunity arises. Most progress has been made in Uganda (owing to the appointment of the two rangers already mentioned) and in Kenya; there is a wide open field in Tanganyika. In all three territories enquiries and specimens are sent from time to time by forest officers, but it is not to be expected that these busy officers can give sufficient attention to the necessary observation and collection: that is a specialist job.

However, we are beginning to appreciate the situation, at least in Kenya and Uganda. From our records it should be possible not only to note potentially dangerous species, but also to forecast their probable behaviour under various conditions. In the natural forest insect damage is usually tolerable, but the often profound changes in the constitution of the forest resulting from scientific management may lead to trouble: the establishment of pure plantations, especially of exotics, for example.

Intelligence Service

Records.—Information is classified (a) in a card index showing species of insects associated with particular tree species, and (b) in ledger files, arranged under insect species, in which all available data are noted. Owing to shortage of staff, these still need bringing up to date.

Reference Collection of Insects.—We are indebted almost entirely to the Commonwealth Institute of Entomology, London, for the accurate identification of the insects in this collection which is increasing quite rapidly. It is remarkable that a large proportion of the specimens sent to London is either new to science or absent from the British Museum collections, as might be expected when exploring a practically new field. The insects in our collection are all associated with biological information.

A collection of named larvae, especially of wood-boring Coleoptera and of Lepidoptera, is being built up for future classification. Since at present it is necessary to rear larvae to the adult stage for identification, usually a lengthy process, rapid diagnosis from the larva alone will be a great advantage.

Oemida gahani Distant.—This Cerambycid beetle is so far the most serious pest in Kenya; it has not yet been recorded as a pest in Tanganyika although occasional specimens have been caught there; there are no records from Uganda, but an exploration of the west side of Mt. Elgon now in progress may reveal its presence. This beetle is essentially a dead-wood borer, being common in structural timber (especially Podocarpus) and in many species of dead trees, stumps, etc., in the forest; its particular importance is that it can breed in the centre of living stems of exotic conifers (and probably other species) when access is available through areas of dead wood on the outer surface; such areas may be provided by pruning scars or by wounds made by animals. There appears to be no reliable means of discovering whether a living tree is attacked or not, but on felling and sawing, as much as 80% of the trees (cypress in this case) have proved to have been riddled internally by the galleries of the larvae.

Particular attention is being given to this insect, and a special field station has recently been opened at Londiani (under Mr. J. O. Evans, Kenya Forest Department, with guidance from the forest entomologist) for field observations; laboratory work is being done at Muguga. While considerable progress has been made, there is still much to be done in this long-term research. It is practically certain that if pruning were abolished, incidence of attack would be tolerable; if pruning is to be continued, two lines of investigation are improvement in technique and doping of scars, both being dealt with by the silviculturist of Kenya Forest Department.

Borers of Seasoned Wood (*Powder Post Beetles*).—A considerable amount of information on the numerous species concerned (Bostrichidae, Lyctidae) has been accumulated. An interesting point is that whereas in India no case of a coniferous timber being attacked by these beetles is known, such attack is common in East Africa. Attack is limited to wood containing certain substances, one of which is starch; these are found in all normal sapwood and if sapwood is to be used for industrial purposes it should be chemically treated. The implementation of such treatment is under active consideration in the three territories. It may be noted that such treatment will result in the use of much timber hitherto regarded as of little value. A note on this subject was published in the *East African Standard*.

Other Problems.—All three territories are interested in the control of *Phytolyma lata* Scott, a Psyllid known as the Mvule Gall Fly; areas affected by this in Uganda and Kenya have been inspected and it is hoped to start experiments to discover an effective and economic spray technique. Considerable damage by termites in plantations has been recorded. Defoliation by Lepidoptera has so far been negligible, but epidemics at some future date may be expected judging from experience in South Africa and elsewhere. Apparently alarming attacks on *Pinus radiata* in Kenya in 1950 and 1951, during which many acres were completely defoliated by a bagworm (*Acanthopsyche aethiops* Hamps.), were not resumed in 1952. The reason for this is not known as no parasites were found in mass rearing experiments.

Systematic Botany

STAFF

P. J. Greenway ..... *Botanist-in-Charge*
B. Verdcourt ..... *Botanist*
Count A. E. Starzenski ..... *Scientific Assistant*

The year 1952 has been a notable one for East African botany since three parts of the long-awaited Flora of Tropical East Africa, namely those dealing with the families Ranunculaceae, Marantaceae, and Oleaceae, have been published. This marks the beginning of a Flora which will deal with 188 families; a task undertaken by the Director and staff of the Royal Botanic Gardens, Kew, helped by additional staff financed by the Colonial Development and Welfare Scheme. The preparation of this Flora will take many years, but it is intended to publish it family by family as each becomes ready. Another welcome and long needed book to the literature of East African botany was the publication of a revised and enlarged edition of Eggeling's "Indigenous Trees of the Uganda Protectorate" by the Government of the Uganda Protectorate. The first edition had long been out of print and this second edition revised by Mr. I. R. Dale, Forest Department, Uganda, with its coloured plates, additional photographs and line drawings is a great improvement on the first.

The full complement of the herbarium staff was not completed until April when Mr. B. Verdcourt returned from vacation and a study period at the Royal Botanic Gardens, Kew.

About a hundred visitors from many regions as well as from East Africa called at the Herbarium. Of these Mr. A. V. Bogdan, Department of Agriculture, Kenya; Dr. J. B. Gilliland, Botany Department, Witwatersrand University, and Dr. G. W. Reynolds, Johannesburg, South Africa; Mr. J. B. Gillett, the Herbarium, Royal Botanic Gardens, Kew; Dr. P. W. Carter, Botany Department, University College of Wales, Aberystwyth; Mr. J. Seldon, Prince of Wales School, Nairobi, Kenya; Mr. W. G. Dyson, Forest Department, Kenya; Mr. M. S. Parry, Forest Department, Tanganyika; Messrs. J. D. Jameson and D. G. Thomas, Agricultural Department, Uganda; Messrs. K. M. Guichard, G. B. Popov and C. F. Hemming, Desert Locust Survey, Mr. B. Anderson, Overseas Food Corporation, Nachingwea, Tanganyika; and Mr. F. White, Imperial Forestry Institute, Oxford, made full use of the Herbarium and Library.

By the end of November the building of quarters for two married Africans and one single African was completed in the Coryndon Museum grounds, with funds provided by the three East African Governments, and these rooms are now occupied by the more senior of the African staff. Reasonable housing for the remainder still remains a problem.

The Herbarium

One hundred and eighty-six accessions of botanical material were received during the year totalling over 4,400 specimens for naming, 1,547 named and 61 loaned.

The more important of the unnamed collections were from:—

Arabia.—Desert Locust Survey, 1,171 (Messrs. H. B. Gilliland, 235; K. M. Guichard, 582; F. W. Lee-Oldfield, 275; G. B. Popov, 72; and R. C. Rainey, 7).

Eritrea.—Desert Locust Survey, 112 (Messrs. H. B. Gilliland, 19; and P. Townsend, 93).

Ethiopia.—Desert Locust Survey, 31, Mr. Adefris Bellehu.

Kenya.—Agricultural Department, 171 (Messrs. A. V. Bogdan, 43; R. W. Rayner, 57 all named; and Mr. V. R. S. Beckley, 38 unnamed). The Coryndon Museum, 37 (Messrs. P. R. O. Bally and J. G. Williams, 7). The Desert Locust Survey, 47, Mr. Hemming. The East African Agriculture and Forestry Research Organisation, 272 (Messrs. Eastop, Hesse, May and Trapnell). The East African Herbarium, 401 (Messrs. P. J. Greenway, 15; E. Kirrika, 66; Count A. Starzenski, 64; B. Verdcourt, 77; and G. Williams, 158). The E.A. Tsetse and Trypanosomiasis Research and Reclamation Organisation, 17, Mr. J. Ford. The Forest Department, 154, the majority by Mr. W. G. Dyson. Mr. J. B. Gillett of Kew, attached to the Kenya-Ethiopia Boundary Commission, packing cases of specimens and about 76 packets of seeds for transmission to the Royal Botanic Gardens, Kew. Messrs. Grahame Bell, 42; Pest Control (E.A.) Ltd., Ruiru, 199, mostly by Mr. Cunningham van Someren. The Veterinary Department, 16, Dr. P. Thorold. Sundry private collectors, 62.

Somalia.—The Desert Locust Survey, 303 (Messrs. K. Guichard, 262; and G. B. Popov, 41).

Tanganyika.—Agricultural Department, 30 (Mr. N. R. Fuggles-Couchman, 23 rice field weeds); E.A. Herbarium, 34 (Messrs. P. J. Greenway and G. Williams); the East African Medical Survey and Filariasis Research Unit, 33 (Native food and medicinal plants); Forest Department, 661 (Messrs. W. J. Eggeling, M. Gane, J. S. Groome, J. F. Hughes, M. S. Parry, J. E. A. Proctor, S. Semsei, G. Watkins, L. G. T. Wigg and others); the Government Chemist, Dar es Salaam, 23 (Native medicinal and poisonous plants); the Overseas Food Corporation, 109, Mr. B. Anderson; the Soil Conservation Service, 5; Water Development, 8 , Mr. K. F. Lewis; the Veterinary Department, 232, Mr. H. J. van Rensburg.

Uganda.—The Agricultural Department, 28, J. W. Purseglove; the Forest Department, 189 (Messrs. I. R. Dale, H. C. Dawkins, G. J. Leggat, H. A. Osmaston, G. Webster, G. H. S. Wood and J. E. M. Stephens). The Hydrological Survey, 54, Mrs. E. M. Norman.

In addition species of *Pentas* and *Cuscuta* were sent from the Jardin e Museu Agricola do Ultramar, Lisbon, Portugal, the Botanical Museum, the University, Lund, Sweden, and the Royal Botanic

Gardens, Kew, for Mr. B. Verdcourt to name. About 1,000 specimens of Rubiaceae were also examined by Mr. B. Verdcourt whilst at Kew These included 600 from the Herbarium of the Botanic Gardens, Brussels.

Of about one thousand five hundred named specimens received the bulk came from the following: The Conservator of Forests, Salisbury, Southern Rhodesia, 21 illustrated descriptions of trees common to East Africa; the Botanical Museum, the University, Lund, Sweden, 11 *Pentas* spp.; the Imperial Forestry Institute, Oxford, 43 tree species; the Missouri Botanical Garden, St. Louis, U.S.A., 721 African; Museum National d'Histoire Naturelle, Laboratoire de Phanerogamie, Paris, photographs of the type of *Gigasiphon humblotianum* (Baill.) Drake; the National Herbarium, Pretoria, South Africa, 87 Portuguese East African plants; the New York Botanical Garden, New York, U.S.A., 103 Nyasaland plants collected by Dr. L. J. Brass on the Vernay Nyasaland Expedition in 1946; the Royal Botanic Gardens, Kew, 350 Portuguese East African, Northern Rhodesian and Tanganyika plants, the majority collected by Mrs. H. C. Faulkner; Mr. B. Verdcourt, 100 British plants, the latter a most useful donation as we are receiving an increasing number of European plants to name that are now appearing as weeds in the East African flora.

Over five thousand three hundred specimens were distributed to various institutions amongst the more important being: The Royal Botanic Gardens, Kew, 938 specimens; Missouri Botanical Garden, St. Louis, U.S.A., 514; the National Herbarium, Pretoria, 152; the British Museum, Natural History, London, 312; the New York Botanical Gardens, New York, U.S.A., 150; Government Departments in East Africa, 187 and various firms and private individuals in East Africa, 87.

One hundred and fifty-seven sheets of *Pentas* and related genera loaned to the E.A. Herbarium for study by Mr. B. Verdcourt were returned to their respective herbaria at Berlin, Durban, Kew, Lisbon, Lund, Pretoria and Zurich.

Loan material comprising 1,798 sheets of sixteen families was sent to the Royal Botanic Gardens, Kew, for study for the Flora of Tropical East Africa; 314 sheets of *Lobelia* spp. to Prof. F. Wimmer, Naturhistorisches Museum, Wien, Austria; 199 sheets of *Kalanchoe* spp. to Dr. Raymond-Hamet, Rue de Glaciere, Paris; 30 sheets of *Bidens* spp. to Dr. E. E. Sherff, Chicago Natural History Museum, Chicago, U.S.A., and 3 *Najas* spp. to Dr. Horn of Rantzien, Botanical Department, Naturhistoriska Riksmuseet, Stockholm, Sweden.

The East African Herbarium is being used as a base by Mr. J. B. Gillett, a Colonial Office Botanist from Kew, working with the Kenya-Ethiopia Boundary Commission. Cases of botanical specimens and many packets of seeds as well as pickled material have been forwarded through the Herbarium to Kew on behalf of Mr. Gillett, who has also been loaned collecting material such as presses and drying paper.

In addition over 500 specimens collected in Arabia by members of the Desert Locust Survey were sent to the British Museum Natural History, London, and a second set of this collection has been deposited here. No attempt will be made to name these plants as there are no authentically named specimens of the Arabian flora represented in the East African Herbarium. Nevertheless a few of the more important species were named for the collectors.

Seeds of *Delphinium, Lippia, Adenium, Ricinus, Calpurnia, Gossypium,* and *Cassia* have been sent as far afield as America, England, Uganda, Kenya, Tanganyika, Nyasaland and South Africa for trial and investigation. Pickled and dried material of *Catha* and *Dioscorea* has been sent to two manufacturing chemists in London for chemical investigation.

Over three thousand eight hundred plants were named, questions answered and information supplied on a wide variety of subjects, not only to government departments and private individuals throughout East Africa but to correspondents in Guatemala, the U.S.A., Madagascar, France, Mauritius, Holland, Germany and Switzerland.

In the course of naming collections and amalgamating the two herbaria a further 38 type specimens were found. The following new species were described from the herbarium:—

Agathisanthemum assimile Brem. (Rubiaceae) in *Verhandl. der. Kon. Ned. Akad. Wetensch. Afd. Nat.* 48, p. 159 (1952). *Lunan* H 86/46! isotype.

Baikiaea ghesquaireana J. Leonard (Caesalpiniaceae) in *Bull. Jard. Bot. Brux.* 21, p. 130 (1951). *Busse* 3119! isotype.

Becium albostellatum Verdcourt (Labiatae) in *Kew Bull.*, 1952, p. 364. *Koritschoner* 2044! holotype.

Bidens cinereoides Sherff (Compositae) in *Bot. Leafl.* 5, p. 21 (1951). *van Someren* 1166! holotype.

B. incumbens Sherff, l.c. p. 19 (1951). *Napier* 1016! holotype.

B. insignis Sherff, in *Bot. Ser. Field. Mus.* 17, p. 591 (1939). *Brodhurst-Hill* 612! isotype.

B. lineata Sherff var. *tenuipes* Sherff in *Bot. Leafl.* 5, p. 16 (1951). *Bally* 141! holotype.

B. meruensis Sherff, l.c. p. 18 (1951). *van Someren* 3929! holotype.

B. napierae Sherff, l.c. p. 17 (1951). *Napier* 218! holotype.

B. nobolis Sherff in *Bot. Ser. Field Mus.* 17, p. 593 (1939). *Rogers* 133! isotype.

B. palustris Sherff var. *nematomera* Sherff in *Bot. Leafl.* 5, p. 16 (1951). *Brodhurst-Hill* 215! holotype.

B. rueppellii Sherff var. *incisior* Sherff, l.c. p. 16 (1951). *Pierce* 2568! holotype.

B. rueppellioides Sherff, l.c. p. 20 (1951). *Battiscombe* 945! holotype.

B. schimperi Schultz var. *brachyceroides* Sherff, l.c. p. 17 (1951). *van Someren* 43! holotype.

B. taitensis Sherff in *Bot. Ser. Field Mus.* 17, p. 595 (1939). *Napier* 1321! isotype.

B ugandensis (S. Moore) Sherff var. *longisquama* Sherff in *Bot. Leafl.* 5, p. 16 (1951). *Jack* 324! holotype.

Chamaepentas greenwayi Brem. (Rubiaceae) in *Verhandl. der. Kon. Ned. Akad. Wetensch. Afd. Nat.* 48, p. 47 (1952). *Greenway* 6570 pp. isotype.

C. greenwayi Brem. var. *glabra* Brem. l.c. p. 48. *Greenway* 6570 pp. isotype.

Conostomium kenyense Brem. (Rubiaceae) in *Verhandl. der. Kon. Ned. Akad. Wetensch. Afd. Nat.* 48, p. 132. *Leakey* 3466! isotype.

Crepis newii Oliv. subsp. *mbuluensis* Babc. (Compositae) in *Kew Bull.*, 1951, p. 413. *Greenway* 7676! holotype.

Cynometra gillmanii J. Leonard (Caesalpiniaceae) in *Bull. Jard. Bot. Brux.* 21, p. 388 (1951). *Gillman* 1142! isotype.

Dalechampia trifoliata A. Peter ex Verdcourt & Greenway (Euphorbiaceae) in *Kew Bull.*, 1952, p. 355. *Verdcourt* 113! holotype.

Diotocranus lebrunii Brem. var. *sparsipilus* Brem. (Rubiaceae) in *Verhandl. der. Kon. Akad. Wetensch. Afd. Nat.* 48, p. 149 (1952). *Haarer* 2182! isotype.

Fernandoa magnifica Seem. var. *lutea* Verdcourt (Bignoniaceae) in *Kew. Bull.*, 1952, p. 364. *Bryce* in *Eggeling* 6044! holotype.

Floscopa leiothyrsa Brenan (Commelinaceae) in *Kew Bull.*, 1952, p. 207. *Burtt* 3802! isotype.

Jasminum grahamii Turrill (Oleaceae) in *Kew Bull.*, 1952, p. 135. *Graham* 1658! isotype.

Kohautia dolichostyla Brem. (Rubiaceae) in *Verhandl. der. Kon. Ned. Akad. Wetensch. Afd. Nat.* 48, p. 102 (1952). *Glover & Gilliland* 849! isotype.

Lelya osteocarpa Brem. var. *angustifolia* Brem. (Rubiaceae) l.c. p. 183. *Ward* 16! isotype.

Maesobotrya purseglovei Verdcourt (Euphorbiaceae) in *Kew Bull*, 1952, p. 357. *Greenway & Eggeling* 7102! holotype.

Monopetalanthus trapnellii J. Leonard (Caesalpiniaceae) in *Bull. Jard. Bot. Brux.*, 21, p. 133 (1951). *Greenway & Trapnell* 5580! isotype.

Oldenlandia acicularis Brem. (Rubiaceae) in *Verhandl. der. Kon Ned. Akad. Nat.*, 48, p. 269 (1952). *Brodhurst-Hill* 221! isotype.

O. capitata Brem. l.c. p. 242. *Peck* 216! holotype.

O. goreensis (DC.) Summerhayes var. *trichocaula* Brem. l.c. p. 198. *Warnecke* 239! isotype.

O. greenwayi Brem. l.c. p. 207. *Greenway* 2436! isotype.

O. praetermissa Brem. in *Verhandl. der. Kon. Ned. Akad. Wetensch. Afd. Nat.*, 48, p. 253. *Warnecke* 173! isotype.

O. verticillata Bullock ex Brem. var. *trichocarpa* Brem. l.c. p. 200. *Haarer* 2060! isotype.

Parapentas parviflora Brem. (Rubiaceae) l.c. p. 53. *Leechman* 21! holotype.

Pentanisia confertifolia (Baker) Verdcourt forma *glabrifolia* Verdcourt (Rubiaceae) in *Kew Bull.*, 1952 p. 362. *Greenway & Brenan* 8238! holotype.

P. foetida Verdcourt in *Kew Bull.*, 1951 p. 381. *Rayner* 421! holotype.

P. parviflora Stapf ex Verdcourt l.c. p. 383. *Chandler* 672! holotype.

Pseudomussaenda flava Verdcourt (Rubiaceae), l.c. p. 378. *Thomas* 725! holotype.

Ranunculus keniensis Milne-Redhead & Turrill (Ranunculaceae) in *Kew Bull.*, 1950, p. 389. *Rogers* 615! isotype.

Schrebera greenwayi Turrill (Oleaceae) in *Kew Bull.*, 1952, p. 135. *Greenway* 7688! isotype.

Strophanthus zimmermannianus Monach. (Apocynaceae) in *Phytologia* 3, p. 476 (1951). *Zimmermann* 1496! holotype. *Omari bin Bakari* AH. 9787! paratype.

Tephrosia rensburgii Verdcourt (Papilionaceae) in *Kew Bull.*, 1952, p. 358. *Rensburg* 56! holotype.

Thecacoris usambarensis Verdcourt (Euphorbiaceae) l.c. p. 358. *Greenway* 5929! holotype.

Trianthema redimita Melville (Ficoidaceae) l.c. p. 269. *Dale* 700! isotype.

Zenkerella egregia Leonard (Caesalpiniaceae) in *Bull. Jard. Bot. Brux.*, 21, p. 414 (1951). *Greenway* 4683! isotype.

These additional records bring the total number of known types in the herbarium up to 641.

During the year a total of 8,508 specimens were filed in the herbarium, including 3,451 sheets comprising 27 families transferred from the Coryndon Museum Herbarium; 849 were grasses, bringing the grass collection up to 9,065 sheets and the grand total for the herbarium to 79,228 sheets for study.

Books and separates, the latter both printed and in MS. were loaned to correspondents in Italy, Tanganyika and South Africa. Thirty-two photographs of drawings of the flowers, vegetative parts and roots of *Dioscorea quartiniana* A. Rich. were also distributed, as the roots of this plant may prove to be a "minor forest product" in East Africa. The manuscripts of the families Marantaceae and Oleaceae of the Flora of Tropical East Africa were sent from the Royal Botanic Gardens, Kew, for the habitats to be checked and for general comments.

Work on amalgamating the Coryndon Museum Herbarium continues intermittently owing to pressure of other work. Some one

hundred and seven families have been transferred leaving about another one hundred and seven to be worked through. In the course of examining the specimens quite a number of Berlin types are being discovered in the earlier collections of the Herbarium of the Forest Department, Kenya.

Field Work

From the beginning of the year until the end of July the African Herbarium Assistant, George Williams, has spent a day each week in the Arboretum, Nairobi, collecting botanical specimens from the various cultivated exotic and indigenous plants as they came into flower. About 150 species have been obtained; many of the exotics are not represented in the E.A. Herbarium or in the old Forest Department Herbarium.

Since March the African Assistant, Hanery Padwa, has been working with Mr. J. B. Gillett on the Kenya-Ethiopian Boundary Commission in the Northern Frontier Province of Kenya.

From the end of March to the beginning of May another African, Edward Kirrika, was loaned to Mr. P. R. O. Bally, Coryndon Museum Botanist, when he conducted Dr. G. W. Reynolds from South Africa on a botanical survey of East African Aloes in Kenya, Tanganyika and Uganda.

In early July, at the request of the Agricultural Department, Tanganyika, Mr. P. J. Greenway paid a few days visit to the Tanga and Northern Provinces to report on the identities of cultivated *Hibiscus* in fibre trials.

Towards the end of August, Mr. P. J. Greenway was in the Western Usambaras, Tanganyika, and together with the African Herbarium Assistant, George Williams, made a survey of *Podocarpus* spp. on behalf of the Royal Botanic Gardens, Kew, for the Flora of Tropical East Africa. It was established that three species are represented in the area, *P. usambarensis* Pilger, *P. milanjianus* Rendle, the most common, and *P. gracilior* Pilger, less common. Material collected during the survey has been sent to Kew.

In October Mr. Verdcourt, with Mr. W. A. Sands of Termite Research, visited Mt. Moroto, Karamoja District, Uganda, when about one hundred and twenty specimens were collected. This collection has been named and duplicates distributed.

During casual collecting on the shores of Lake Magadi, Kenya, specimens of *Fagonia brugieri* DC. (Zygophyllaceae), originally described from Iran and Syria and recorded in Eritrea, Ethiopia and the Somaliland Protectorate, were gathered, a new and most southerly record for this genus and species in East Africa.

In conclusion thanks are due to Mr. A. V. Bogdan, Pasture Research Officer, Agricultural Department, Kenya, for his help in incorporating all the Gramineae from the Coryndon Museum collection with that of the E.A. Herbarium.

B. Verdcourt

Collections of insects have been continued and material sent to specialists at home. Some insects were collected during a short safari to Mt. Moroto, Uganda, in October and these have been given to the Coryndon Museum. The following insects have recently been described from my material.

Methneria verdcourti Last. in *Ent. Month. Mag.* 88, p. 89 (1952). *Ancylopteryx verdcourti* Kimmins and *Semidalis terminalis* Kimmins in *Entomologist* 84, pp. 136-139 (1951).

Nimboa alibizziae Kimmins, *Coniopteryx notata* Kimmins and *Hemerobius nemorensis* Kimmins in *Entomologist* 85, pp. 186-190 (1952).

Anapochrysa africana Kimmins in *Ann. Mag. Nat. Hist.* (12) 5, p. 929 (1952).

Soil Microbiology

Staff

J. Meiklejohn ..... *Microbiologist*

This report covers only the second half of the year, as I did not arrive in East Africa until the end of June 1952.

As the purpose of my appointment to E.A.A.F.R.O. was to start a programme of work on Soil Microbiology, previously an untouched field of research in East Africa, a large part of my time has necessarily been spent in visits and interviews, to select soil problems which could usefully be attacked by microbiological methods.

I have made journeys in Uganda, Tanganyika and Zanzibar, visiting research stations and farms, and discussing problems with research staff and Agricultural Officers. In Kenya I have been able to discuss soil problems with several members of the Department of Agriculture staff, but so far the Emergency has prevented any visits to research stations or farms.

As a result of these visits and discussions, it now appears that one of the soil problems to which microbiology can most usefully be applied is the question of the supply of nitrogen in soil. In the first place, it seems likely that the poor yields obtained, in many parts of East Africa, from crops planted after grass has been ploughed in, may be a consequence of lack of nitrogen in the soil. One way in which the nitrogen content of soil may be increased is through the activity of nitrogen-fixing bacteria; some of these work in association with leguminous plants; but, as much work has been done elsewhere on tropical legumes, attention is being directed to the other group, the nitrogen-fixers which live free in the soil.

Secondly, it appears that one of the reasons for lack of nitrogen in surface soil is rapid nitrification, as the nitrate formed by this

process is either leached down to the subsoil by rain, or reduced by denitrifying bacteria to nitrogen gas, which escapes into the atmosphere. Because of these processes, sulphate of ammonia may be mostly wasted, if it is applied as a fertiliser at a time when there are not sufficient surface roots in the crop to use the nitrate as fast as it is formed. Very intensive nitrification had previously been observed to take place in the bare fallow plots of an experiment being carried out at Kawanda Research Station, Uganda. Soil samples from this experiment, and also from the E.A.A.F.R.O. farm at Muguga, are therefore being studied to see what nitrifying organisms are present in them. Some work is also being done on methods of counting micro-organisms in soil; both the direct count method of Jones and Mollison, and various indirect methods, are being tried.

Dr. Rudd Jones, who is away from E.A.A.F.R.O. during his tenure of a Canadian National Research Council Fellowship is specially studying modern microbiological methods, at the Prairie Regional Laboratory, Saskatoon, Canada. In view of his earlier work in plant pathology he is giving attention to the carbon and nitrogen substrate utilisation and nutritional requirements of the fungi occurring in certain acid-type East African soils.

Soil Chemistry

Staff

H. F. Birch ..... *Chemist*
G. T. Chamberlain ..... *Spectrochemist*
M. T. Friend ..... *Analyst*
P. R. Hesse ..... *Chemist*
M. Maclean ..... *Scientific Assistant*

General

The work done during 1952 may be sub-divided as follows:—

(1) Soil and miscellaneous analyses.

(2) Soil phosphate investigations.

(3) The examination of some physical and chemical characteristics of termite mounds.

(4) Spectrochemical investigations.

A description of the work is given in the appropriate sections. Broadly speaking three investigations of a fundamental and practical nature are being carried out. Superimposed on this work is the routine analysis of plants and soils mainly for advisory purposes and for the Soil Survey Department. The phosphate investigations are a continuation of those described in the Annual Report for 1951, and further progress has been made. Mr. Hesse has now virtually completed the collection and analysis of samples from termite mounds and adjacent soils and has been able to draw certain definite

conclusions from the data. The work of the Spectrochemistry Section falls mainly into the following three categories:—(a) the application of the medium quartz spectograph to the determination of bases in soils and plants, (b) investigations on nutritional disorders in plants with reference to their base status and that of the corresponding soils, and (c) the setting up, standardisation and use of the new Littrow spectograph for the determination of trace elements.

Soil and Miscellaneous Analyses

Eighteen samples of soil and one of water were received from British Somaliland for analysis, to assist Brigadier Hawes in his survey of irrigation possibilities. The analyses, which included determinations of pH, carbonate, salinity, and individual cations and anions, gave the required information and showed the feasibility or otherwise of certain projects. A further 12 soil and 6 water samples were later received from British Somaliland and similarly analysed.

Analyses of 34 soils from the Lake Province, Tanganyika, were made to see if they are likely to respond to phosphate. From the similarity of their analytical data to those of neighbouring soils of known response to phosphate it is highly probable that they will also respond.

The Soil Survey Department of E.A.A.F.R.O. has submitted 319 soils for analyses comprising mainly exchangeable bases, pH, nitrogen, carbon, sand, silt and clay. Of these samples 252 have so far been analysed. The Spectrochemistry Section has been responsible for all analyses involving the determination of bases, exchangeable or otherwise, in soil and plant material.

Phosphate Investigations

H. F. Birch

The inverse relationship in acid soils between phosphate response and the percentage saturation of the base exchange capacity (B.E.C.) of the soil (Annual Report for 1951) has been confirmed by data from a further 48 field experiments with wheat, maize and sorghum. The relationship is now based on the results of 104 of the many fertiliser trials laid down by the Fertiliser Research Scheme and the Highland Fertiliser Scheme.

Crop	*District*	*Year*	*No. of trials*
Wheat	Kenya Highlands	1950	31
Grass	Kenya Highlands	1950	19
Millet	N. and S. Nyanza	1950	19
Maize	N. Nyanza	1951	14
Sorghum	N. Nyanza	1951	23

It has been found that phosphate responses are significantly and inversely related to soil pH but not quite as significantly to the

percentage saturation of the B.E.C. A marked advantage however in the use of soil pH is the ease with which it can be determined. With the wheat and grass experiments a further significant and inverse relationship was established between phosphate response and the amount of soil silica extractable either with water or 1% citric acid solution. The regression equations showed that phosphate responses are unlikely with soils containing more than 40 mgm. of water soluble silica or 350 mgm. of citric-acid soluble silica per 100 g. of soil (1:50 soil:solution extraction). Further study of the data then revealed a significant and direct relationship between silica and the percentage saturation of the B.E.C.

Since the pH, silica content and percentage saturation of the B.E.C. are closely interrelated and each, in turn, related to phosphate response, it appears that each characteristic is functioning similarly in indicating the extent to which soil conditions are favourable to the retention of phosphate in a plant-available form. With decreasing base saturation (reflected in decreasing pH and silica content) there is an increasing likelihood of the native soil phosphate being held in relatively unavailable forms associated with the clay colloids rather than in an available form associated with the exchangeable bases. There is therefore an increasing need for, and response to, applied phosphates. Considering that the degree of base saturation, pH or silica content measures only one of a large number of soil characteristics, both physical and chemical, on which soil productivity and crop response depend, it is surprising that such a close relationship exists between these and phosphate response.

Phosphate response in these investigations is calculated as a percentage, as follows.

$$\frac{\text{Av. yield on P plots} - \text{av. yield on no-P plots}}{\text{Av. yield on no-P plots}} \times 100$$

With low base saturated soils (below about 55%), in which appreciable phosphate responses may be expected, the magnitude of response, expressed as above, will to some extent be governed by the denominator, i.e., the yield on the no-P plots. This yield value is an integration of several factors, physical, chemical and climatic, governing soil productivity. A fairly common feature of the regression of response on base saturation is the scatter, with the lower base saturated soils, of response about the regression line. It was found that in general this scatter could be related to the yield on the no-P plots. Thus, for a given degree of base saturation, higher percentage phosphate responses may be expected if the yield on the no-P plots is low than if it is high. A consideration of the productivity status of the soil, in conjunction with the degree of base saturation, is therefore of considerable help in assessing the probable magnitude of percentage phosphate response.

As an extension of the foregoing work an attempt is being made to find a chemical method which will measure specifically the amount of available phosphate in the soil. As a preliminary experiment in this direction the amount of available phosphate in about sixty soils has been measured by the amount taken up by plants grown on them,

using a modified Neubauer technique. The percentage saturation of the B.E.C. and the amount of acid-soluble phosphate were also determined. The acid-soluble phosphate values were obtained by subtracting the amount of adsorbed phosphate extractable with neutral ammonium fluoride from the phosphate extractable with acidified ammonium fluoride. The amount of available phosphate in the soil was expressed as a percentage of the amount of acid-soluble phosphate, and this percentage (Y) was then related to the percentage saturation of the B.E.C. (X).

The following equation was derived.

$$Y = 0.0001955\ X^3 - 0.02803\ X^2 - 1.34535\ X - 20.684.$$

Thus from this equation for 90, 80, 70, 60, 50 and 40% saturation of the B.E.C. (X), respectively, 15.9, 7.6, 8.2, 1.4, 0.9 and 0.8% of the acid-soluble phosphate in the soil is in an available form. From 90 to 70% saturation of the B.E.C. there is a rapid fall in the Y values, while below 60% saturation of the B.E.C. only about 1% or less of the acid-soluble phosphate appears to be available. From this equation an estimate of the amount of available phosphate in a soil can be made if the percentage saturation of the B.E.C. and the amount of acid-soluble phosphate is known. The method is tentative because it is based on the assumption that all the available phosphate in the soil was taken up by the plants. Under the conditions of the experiment it is by no means certain that this was so. The water-holding capacities of the soils appeared to have an important bearing on root distribution and consequently on phosphorus uptake. The experimental technique can, however, be improved and the preliminary experiment at least serves to indicate the feasibility of this method of approach to the problem of measuring available phosphate and to emphasise the importance of the degree of base saturation in governing phosphate availability in acid soils.

Related Investigations

Grass.—Through the courtesy of the Director of the Tea Research Institute, Kericho, 16 Napier grass samples, one from each plot of a 2^4 factorial experiment with N, P, K and Ca, were made available for analysis, together with three soil samples (0-9″, 9-18″ and 18-27″) from each of the plots. The soils and grasses were analysed for phosphorus and bases. The percentage saturation of the B.E.C. of the soils was low, about 40%, and significant phosphate responses were obtained. This is in accordance with the base saturation/phosphate response relationships already discussed. The grasses from the P plots were found to contain a significantly higher percentage of P than those from the no-P plots. No relationships were found between the base status of the plants and soils, nor between the P status of the plants and the base status of the soils and plants. These observations parallel those made previously (see Annual Report for 1951) with grass samples from the Highland Fertiliser Scheme trials.

Pyrethrum.—Plant and soil samples from four successful fertiliser trials in the Southern Highlands, Tanganyika, have very kindly been

made available by the Agricultural Officer in charge of the experiments, through the Department of Agriculture, Tanganyika. The analyses of these samples, 216 soils and 81 plants, are not yet complete and no conclusions have so far been drawn.

Southern Rhodesia.—The phosphate response/base saturation relationship found here is now being studied by the Ministry of Agriculture in Southern Rhodesia, where the behaviour of crops to applied phosphates has not hitherto been too satisfactorily explainable on the basis of soil-phosphate measurements. A full account of this aspect of their work is given in the Rhodesia Agricultural Journal for May-June, 1952.

Study of the Soils of Termite Mounds

P. R. Hesse

As reported last year, a systematic study by chemical and physical methods of analysis is being made of the soils of the large termite mounds in East Africa. Because of the large number of these mounds and their effect, beneficial or otherwise, on crops, an elucidation of the main chemical and physical characteristics of the mounds has an important bearing on East African agriculture. The object of the work is, therefore, to determine these characteristics, and relate them to the species of termite and ecological factors, such as soil type and climate. The investigation is now very near completion and certain definite conclusions can be stated.

Visits were made to Tabora, Mwanza, Musoma, Bukoba, Arusha, Moshi, Same, Tanga and Mwakijembe in Tanganyika; Kampala and Kiziba in Uganda; and Kisumu, Kajiado, Magadi and Thika in Kenya. Termite mounds and their environment were studied in all these districts and 450 soils were collected from 45 mounds bringing the total to 56 mounds sampled altogether. Rocks, plants, termites, fungus comb and water samples were also collected for analysis. A total of 14,730 analytical determinations have been made this year: of these 13,500 were routine determinations on the soils (i.e. each soil has had 30 different measurements made on it), 278 were made in connection with the structure of the soil as distinct from mechanical analysis, 117 were special analyses on the calcium contents of certain soils and 295 were on fungus comb and termites.

Conclusions

This work has been confined to those mounds built by the genus *Macrotermes,* of which there are three species.

The main conclusion is that termite mounds are built entirely from subsoil collected from a depth of from two to four feet. This holds good for the mounds of all three species, regardless of the soil type, being limited only by the depth of soil above the underlying rock. This is shown by both the chemical and the physical analyses which also reveal the important fact that the termites do not alter or affect the chemical status of the soil in any way whatsoever. All that the insect does is to carry up the subsoil and make a mound of

it; the chemical and mechanical composition of the soil from that mound is entirely dependent upon that of the nearby subsoil. This fact in itself goes a long way to explain the wide discrepancies in analytical results reported by various other workers. Where one investigator found a mound very rich in phosphate, for example, it merely means that the subsoil of that particular district had a high phosphate content and it is not surprising that another worker in a different locality should find the apparently contradictory fact that a mound is exceptionally poor in phosphate. While a mound is in occupation, there is a localised concentration of organic matter and minerals in the central "hive", an area filled with fungus gardens. As far as the organic matter is concerned, this increase is purely temporary and when the termite colony dies out it does not leave behind a carbon and nitrogen enriched soil. The increase in minerals can be detected in a recently evacuated mound, but not in an older, much eroded one.

Early on in the investigation it was realised that a very important factor was whether or not a mound was occupied, and a sampling procedure was adopted to include both inhabited and uninhabited mounds of all three species on as many different soils as possible. Whilst a colony is in occupation, the soil is continually moved about in the mound; new tunnels and chambers are made, walls are replastered and the size of the mound is continually being increased. This activity successfully resists all weathering and erosion effects, and the soil remains constant in composition. However, when the mound is left derelict it proceeds to weather precisely as would any other heap of subsoil. It is at this stage that the ecology of a mound becomes important, for it depends upon the soil type and the microtopography exactly *how* that mound will weather. In most cases no greater changes occur, the mound becoming gradually rounded off, more widespread and eventually grassed over. When a mound occurs in association with poorly drained soils, however, considerable chemical changes can and do take place. There appears to be a definite correlation between low-lying soils with impeded drainage and the large, dome-shaped mounds, and it is in these mounds that concretions of lime and concentrations of salts are found.

Much has been written about the vast deposits of chalk found in termite mounds; but I have never found a calcareous mound except in or near to ground with impeded drainage and in most cases seasonally waterlogged. No concentration of calcium carbonate has been found in an inhabited mound, except when it has been built of soil already calcareous — very often from an older, eroded mound. It can be definitely stated that termites do *not* deliberately collect calcium carbonate and concentrate it in their mounds. The explanation appears to be the purely physical one of a large heap of soil being repeatedly inundated with calcium charged ground waters. The alternate wet and dry seasons would eventually lead to actual concretions, but obviously a considerable time factor is involved. The large masses of calcium carbonate found in some old mounds have been formed over a very long period. As regards the original source of the calcium, this must have come from the parent rocks in the district; it is possible that the fungus garden material, which is very rich in calcium, provides a small nucleus of mineral matter,

but so many non-calcareous mounds (which also had contained fungus gardens) have been found that this point is somewhat uncertain.

Where crops are found to grow better on termite mounds, and if the latter are calcareous, the calcium concentration no doubt is a partial explanation of the better growth, particularly in the case of sisal and other calciphilic plants. An even more important factor, however, is that of drainage; although, as has been emphasized, the mounds soils have the same mechanical composition as the adjacent subsoils, the structure is very different. This is understandable when one considers that a mound is built up grain by grain by very small insects. The structure has been found in every case to be better than that of the nearby subsoil, and this fact, coupled with that of the increased elevation and depth of soil (particularly in areas of shallow soil or impeded drainage), will contribute much to the better growth of certain crops.

Practical Consequences

1. It is unwise to spread the soil of termite mounds on the surrounding land as this is equivalent to spreading a layer of subsoil above the topsoil.

2. If the labour of digging out the large mounds is considered worth the results, then these can provide a considerable quantity of impure lime, but it must be remembered that such concretions do not occur in all mounds. The most likely are the very large, old, dome-shaped ones in grey earth and in or near to seasonally water-logged ground.

3. As a source of road surfacing and brick making material termite mounds are convenient, because they are as heaps above ground, but can give no better results than would the normal subsoil of the district. The calcareous heaps are a special case.

When the work is finally completed, a detailed account will be published.

Spectrochemistry

G. T. Chamberlain

The past year has been one of extension in the application of spectrochemical analysis to East African agricultural problems and a larger number and variety of samples have been analysed. The arrival of the Littrow spectrograph is a large step forward, but the late delivery of the instrument and accessories has delayed the programme.

Flame Analysis

Technique.—In addition to the alterations described in the Annual Report for 1951, an electromagnetic shutter and synchronous timer have been added to the instrument.

The photoelectric cells and filters required for direct reading of potassium contents arrived during the year and preliminary experiments have been very promising.

Soil Analysis.—During 1952 the flame spectrograph was in continuous use under the control of Miss Maclean and a total of 1,006 samples have been analysed for acetate extractable bases. These soils consisted of 125 for the O.F.C., 32 for the Tea Research Institute, 22 for the sisal investigations, 133 for the Soil Survey Section, 250 for Tanganyika Department of Agriculture, 30 from Somaliland, 6 from Northern Rhodesia, 8 for the Geneticist, 7 for the Plant Physiologist and 20 from the Muguga Farm, and 372 for the Termite investigations. In addition to the above some 293 acid or water soil extracts were analysed.

Plant Analysis.—A further batch of 22 sisal samples taken from a fertiliser trial were analysed. For leaf tip die-back disease no significant relationships between disease and soil or plant composition were found. For parallel streak disease inverse relationships were found at P.=0.05 level between the number of diseased leaves per plot and the leaf weight and the soil Ca/P ratio. A direct relationship held between the number of diseased leaves and C/N ratio but further statistical study is necessary and the analysis of many more samples.

For the routine accumulation of data, samples of barley, sunflower, lupin and various silage from Muguga Farm were analysed with their associated soils and a very high manganese content in the lupin was observed (approximately 0.7% in oven-dry matter). This was also reflected in a sample of mixed maize and lupin silage, which showed a manganese content of around 0.25%.

Six samples of grass were analysed for the soil physicist, 8 cassava leaf samples for the geneticist, 2 pyrethrum for the plant physiologist and 16 grasses for the Tea Research Institute.

Other Analyses

The Spectrochemical Section has been called upon to analyse a variety of substances which can be dealt with more simply than by chemical methods, and these included, in 1952, two samples of river water and one of lake water for the E.A. Fisheries Research Laboratories, Jinja, and also a sample of phytoplankton for the same organisation.

Seven samples of well water from Somaliland, 5 samples of fertilisers, 16 extracts from termite fungus combs and 4 extracts from termites were also analysed during the year.

Minor Element Analysis

The Littrow spectrograph was received in June, but it was not possible to start work with the instrument until the arrival of the rectifier. Serious work was not started until October. These deliveries being much later than expected had made it impossible to have the technique established by the end of the year.

Three basic methods are being put into practice, the concentration method for cobalt, molybdenum, vanadium, chromium, tin, lead, gallium, germanium, nickel, beryllium, silver and zinc, the direct method on plant ash for copper, manganese, iron, barium, and strontium, and also the major elements, sodium, calcium and magnesium, and a third method for boron.

The relative priorities to be given to these methods caused some difficulty as all seemed to be in great demand from various parts of the territories. As samples for B. determination had already been received from the Animal Industry Division, this was given first priority and the method is now almost ready for use.

For all methods it has been necessary specially to purify many chemicals, and now the stage has been reached for the preparation of standard mixtures for the other two methods; for the concentration method alone forty-two mixtures are necessary (seven fixed iron contents each containing six dilutions of the minor elements).

At the special request of the Forest Entomologist two samples of Cypress were analysed for chromium, one being the periphery and the other being the core of a 4″ x 2″ beam impregnated with insecticide. Results showed that the treatment had not penetrated the core, where the Cr. content was 4.4 p.p.m. (based on oven-dry wood) compared to 2,750 p.p.m. for the periphery.

Advisory Work

In February a visit was made to the Sisal Experiment Station, Ngomeni, T.T., to plan the modifications required in an existing laboratory to convert it to a spectrochemical laboratory. A fully detailed plan was made and left with Mr. Diekmahns to arrange for the necessary alterations. In July, a further brief discussion was had with Mr. Lock and Mr. Diekmahns during a visit to Muguga.

The purchase by the Uganda Department of Agriculture of the spectrochemical equipment for the Lundegardh flame method involved a visit during September to the Kawanda Research Station. Details of the method had already been communicated to Dr. Chenery, Senior Research Chemist, and the required solutions were ready on arrival. The instrument was set up and instruction given to Dr. Chenery on its use.

On the way to and from Uganda, brief talks were had with Mr. G. Fish of the E.A. Fisheries Research Laboratories, and it was agreed that, as opportunity offered for sampling, the lake waters of Kenya would be analysed and also further samples of river water and phytoplankton as they became available.

A visit was received from Dr. Nefdt, Government Chemist, Kenya, and Dr. Timms and Dr. Dockery of the Medical Research Laboratories to discuss the spectrochemical or flame photometric analysis of biological materials.

In September, 1952, a talk with slides and illustrations was given to the Nairobi Scientific and Philosophical Society. The medium spectrograph, the microphotometer and accessory equipment were exhibited after the talk.

Soil Physics

STAFF

H. C. Pereira ..... *Soil Physicist*
P. H. Hosegood ..... *Scientific Assistant*

Two main lines of investigation are being followed. The first is on the build up and decline of soil structure in grass-ley rotations under East African conditions. The second is on the water balance between soils, plants and atmosphere under conditions in which the roots of the plants are not influenced by a water table in the soil.

Soil Structure Studies

In the soil structure measurements, volumetric techniques with undisturbed cores are employed, and are compared with both wet and dry soil-sieving techniques, in order to check the reliability of "crumb-structure" estimates under tropical conditions. In Kenya, work has continued on the grass establishment trials at Makavete (near Machakos), where changes in pore-space and percolation rates are being followed in a Rhodes-grass ley on eroded sandy Basement-complex soil; similar measurements, and also the changes in resistance to artificial rainfall, have continued at Ruiru, on a friable lateritic clay "loam." Progress reports on both of these studies have been published during the year. In Uganda, a joint study was begun with Messrs. Chenery and Mills, of the various structural effects brought about by one of their rotation experiments at the Kawanda Research Laboratories. In Tanganyika, the measurement of changes in both soil structure and soil moisture storage were continued in the rotation experiment begun at Kongwa in 1951. Field measurements at Kongwa were supplemented by laboratory work and calculations at Muguga. Further details of this investigation will be found in the O.F.C. section on page .....

Soil Effects of Leys

An outstanding feature of the structure measurements has been the remarkably rapid deterioration in the physical conditions of East African soils which has followed the ploughing up of grass leys. Measurements at this stage suggest that organic matter plays a different rôle in soil aggregation in tropical and in temperate zones.

Since much capital and efforts is now being devoted to the establishment of ley-farming systems in East Africa, it is most important to obtain a better physical basis for the planning of grass rotations. A large scale series of experiments was, therefore, initiated on the new farm at Muguga during the year, for the study of contrasting rotations, laid out both on terraces and on long slopes, from both of which runoff can be measured through a series of concrete Venturi channels (Parshall Flumes). Sites were selected with the aid of officers of the Kenya Soil Conservation Service, and work on their preparation was begun during the year.

Water Balance Studies

The water-balance studies currently in progress include a range of climatic conditions from forests on the catchment area of the Aberdares, through Kikuyu grass pasture and plantation coffee to cereal crops in the dry conditions of Kongwa. In all of these studies, gypsum blocks are in use, in combination with periodic deep soil sampling, to follow quantitatively the soil-moisture storage changes. Particular attention has been concentrated during 1952 on the 11-acre Kikuyu grass catchment area, where soil moisture sampling, at one-foot intervals to 10 feet, has been carried out three or more times a week.

The very large proportion of the rainfall which is stored and lost by transpiration at relatively high soil-moisture tensions under this deep-rooted grass is an important factor for catchment-area management. Evaporation estimates, relating open water losses, atmospheric conditions and solar radiation to measured soil moisture changes under crop roots, have been continued at altitudes of 5,400 feet and 7,600 feet, and have been started during the year at Muguga (6,800 feet), where a first order Meteorological Station is being set up on a site selected, in consultation with the East African Meteorological Service. Instruments received during the year have been tested and mounted. The methods of Dr. H. L. Penman of Rothamsted have proved successful in estimating open water losses in Kenya conditions, and their relation to soil-moisture losses is being studied.

A five-year accumulation of daily rainfall recordings, made by the Kenya Forest Department from over 40 gauges in an interception experiment on forest canopies, have been card-indexed and analysed. The results have been published, and the hyperbolic interception curves show a remarkable similarity of behaviour by cypress plantations, indigenous bamboo, and a hardwood forest in North Carolina. Data for the latter were kindly supplied by Dr. C. R. Hursh, Director of the Forest Influences Department of the Coweeta Hydrological Laboratory in the U.S.A. With Dr. Hursh a joint field study was carried out on the Shimba Hills catchment area which supplies Mombasa. Here the disposal of rainfall under grass and forest cover was explored by soil sampling, and recording of soil and air temperatures, humidity, evaporation and condensation of dew.

Continuation of Coffee Research at Ruiru

On transferring to E.A.A.F.R.O. at the beginning of the year, I continued responsibility for the conduct of the Soil Science Laboratory at the Coffee Research Station, Ruiru, pending the delayed arrival of an officer to replace me. Unfortunately arrangements for a replacement again broke down, and I remained in charge of this laboratory throughout the year, spending two days per week at Ruiru until October. Thereafter the pressure of Police Reserve duties reduced the time available to one day per week. Apart from incidental advisory duties and committee meetings, this time was devoted to work on soils and data from the group of soil fertility field trials conducted jointly with the Agricultural Officer, Mr. P. A. Jones. Some tilth measurements were made to estimate the effects of rotary cultivation on a soil of known physical properties. The physical

aspects of these coffee experiments will continue, on a long-term basis, as part of my E.A.A.F.R.O. programme.

East African Agricultural Journal

In the absence of Dr. Duthie on overseas leave, I edited the April, June and December issues of the Journal.

Visits undertaken during the year

In January a brief visit was paid to Kongwa to discuss on the spot various aspects of the soil moisture and structure studies undertaken jointly with Mr. R. A. Wood.

In March a two-day Geophysics Conference was attended at the Geological Department, Nairobi.

In October a visit to Njoro was made to give a lecture on "Management of Coffee Soils" to the Edgerton School of Agriculture. In December a similar visit was made to lecture on "The Physical Basis of Soil Conservation Practices."

Later in December, during a 10-day visit to Uganda, soil structure samples were taken at Kawanda, and a brief visit was paid to the Cotton Research Station at Namulonge.

Soil Survey

STAFF

G. H. Gethin Jones ..... *Soil Surveyor*
R. M. Scott ..... *Soil Surveyor*

In January Mr. Scott, who had had experience of soil survey work in the Gold Coast, started duties as a second member of the Soil Survey Section. This made possible a larger amount of survey work including detailed field mapping.

One major task has been the continuation of field studies of the different kinds of soils and their generic relationships as a basis for working out a first system of soil classification. The recording of soil conditions and the placing of new soil types has been done while carrying out practical soil surveys over areas where there are suitable base maps. The latter work has been done at three category levels according to the purpose of the surveys. There have been Reconnaissance Surveys along roads and tracks only, but without mapping, over extensive regions. A second form comprises soil survey, including mapping, at about the Soil Association level, aided, wherever possible, by aerial photographs. These two kinds of survey were based on the 1:50,000 Preliminary Plot Maps which are now becoming available. Thirdly, there has been the detailed classification and mapping of special areas using large-scale maps. The latter work, besides providing soil inventories in the form of maps, served the purpose of showing up the transitional morphological conditions

between more arbitrary soil classifications and showed the effect of varied and combined influences of parent material, topography and re-sortment, drainage and vegetation. This study of cause and effect leads to a better understanding of soil formation and aids the Soil Surveyor in anticipating soil sequences and hence in soil mapping.

The Reconnaissance Soil Surveys were made with the duel purpose of initiating land-use surveys with the approximate mapping of main soil types only by departmental officers while, at the same time, specific data was collected on the soil types and their relationship and distribution over widely scattered districts. The co-operative survey will be described under Land-Use Surveys.

The Classification and Mapping of Soil Associations

With a staff of two surveyors it was considered advisable to limit systematic mapping at about the Soil Series level to special areas only and to utilise the facilities available to carry out a rapid mapping of much more extensive regions in less detail at about the Soil Association level. Whereas some of the latter units could readily be sub-divided into Soil Series with different land-use values, most of the field mapping has been done at the Association level. The scale of mapping was governed by the maps that were available, mainly the 1:50,000 (about 1,400 yards to the inch) Preliminary Plot Maps recently published by the Directorate of Colonial Surveys. The parent aerial photographs on about double this scale comprised suitable base maps for field work. With the use of the steroscope, they give a picture of the physical features and, except where there has been excessive clearing, they also show dissimilar vegetal covers, which are often associated with particular edaphic conditions. There is always the need for adequate ground work to check up on the indicated likely soil boundaries. The air photos are especially useful and greatly expedite the mapping of scattered treeless, seasonally wet, black clays and Vlei soils, but in areas under intensive cultivation, they are of very little use, except where sharp differences in relief are known to coincide with soil boundaries. The pattern and the distribution of certain kinds of relic termitaria, including their reflection in the growth of the plantation crops, are often useful in soil identification and mapping. Ten Soil Associations have been classified and mapped over an area of a little more than 200 sq. miles, comprising the lower half of the coffee-growing zone and extending down to the Athi River in the region between Nairobi and Thika.

At the higher altitudes, from about 7,500 feet along about the edge of the Kikuyu Escarpment Forest Reserve down to about 5,500 feet, there occurs a particular sequence of soil conditions with decreasing humidity and altitude. The recurring sequence down the general slope is not due to differential soil movements and drainage, as often found from the crest of a hill to the valley, or due to a different lithological sequence, but has resulted from different degrees of leaching. The resultant morphological conditions comprise a continuous variant with no clear boundaries, though the total change over a distance of about 15 miles down the long ridges between the consequent streams, with a rainfall decreasing from about 60 to 40 inches and an elevation difference of about 2,000 feet, is pronounced. The changing soil conditions have been arbitrarily classified into

four soil types, with a fifth non-zonal type occurring dispersed on broad ridges where there has been little geological erosion. The means for the classified soils have a characteristic morphology and base saturation and there are also slight differences in climate. In this region of the African Reserve, where air photos show only a patchwork of intensive cultivation and where the classified soils merge into each other, any mapping based on the use of the soil auger even at the Soil Association level would be very laborious and, at best, only approximate. Arbitrary boundaries of the zonal soil belts have been indicated on roads and tracks not more than two miles apart and then projected along the slopes, after allowing for the known influence of varying relief on soil distribution. It was noted that soil fertility and peasant land usage could be correlated with the above-mentioned soil changes. Such a system of survey has been done over a densely populated region of about 250 square miles from a few miles to the east of Uplands to near the Maragwa River.

While carrying out the above and other surveys, the opportunity was taken to study further the morphology and distribution of the Great Soil Groups. The climatic soil types range from highly leached lotosols to calcareous black clays. The combined effects of geology, topography and drainage have given rise to a wide range of soils, including those with concretionary laterite or 'murram', both as a soil horizon, and as a parent material.

Detailed Soil Surveys

Detailed surveys involving the classification and mapping of Soil Series and phases of same, have been done for Muguga and its environs, totalling about 10 sq. miles, and also for the Coffee Research Station near Ruiru. This detailed work, based on frequent soil augering and the taking of many representative soil-profile samples which were analysed by the Soil Chemistry Section, not only provides soil maps to guide field experimentation and planned development, but also makes it possible to study in detail the influence of different soil-forming factors and the relationships of soils to each other.

In the case of E.A.A.F.R.O. and E.A.V.R.O. lands, there were very suitable base maps on the scale of 1:2,500 (70 yds. to the inch) shewing 5 ft. and 10 ft. contours, respectively, and also air photographs, which made for the accurate mapping of the determined soil boundaries. The area surveyed in detail extended westwards to Sclater's Road, southwards to Lat. 1° 15′, and eastwards to Long. 36° 39′. The geomorphology differs from that of the regions of parallel ridges, with valleys carved out of the same volcanic rocks, that extend north-eastwards along the lower slopes of the Aberdares towards Nyeri. Muguga occurs within the faulted and fractured zone bordering on the Rift Valley and is characterised by an undulating relief with local hills and depressions, but without a defined drainage system. The soils have been classified into nine Soil Series, with three separate soil phases. Of these , three Soil Series and two phases are also found in the typical ridge country. The main Soil Series comprises a deep, sedentary, reddish-brown over a red, friable, lateritic loam, which is also common occurring to the N.E. On more level, higher land and on shelves, where there has been relatively

less geological erosion, there has developed a more fertile, chocolate-coloured soil and, on the slopes, a shallower, more highly coloured soil. Both of these are also found outside the Muguga region. The occurrence of internal drainage, with the accumulation of soils of different texture and subjected to varying degrees of impeded drainage in the depressions, has given rise to many Soil Series that are limited to Muguga, but none of these is extensive. The Soil Chemistry Section has completed the analysis of 252 soil samples taken in connection with the above and other soil surveys. A detailed soil map on the scale of 1:5,000 has been prepared.

The Coffee Research Station, Ruiru, is located in an area with transitional zonal soil conditions between those of the high ridges and those of lower elevations, with low flat ridges and numerous vleis with concretionary laterite formations that, in turn, merge into the plains. Within a small area of about 1 sq. mile, a detailed soil survey showed the presence of Seven Soil Series, with four additional soil phases. The greater portion of the land, and all that planted with coffee, comprises two Soil Series, and one soil phase, which are representative of most of the soils planted to coffee in the Kiambu/Thika district. Some of the remaining Soil Series occurring locally at the Research Station are also found on many of the lower lying coffee estates. A detailed soil map on a scale of 120 yds. to the inch has been prepared.

Land-Use Surveys

These can be conveniently discussed under two headings.

Co-operative Work with Departmental Officers

Most of the widely scattered reconnaissance soil surveys already mentioned were undertaken for the main purpose of initiating a first Land-Use Survey, including the approximate mapping of main soil types only, by Agricultural Officers. This type of survey demands an objective recording of many natural features other than soil conditions. These include topography, soil stability, drainage, the vegetal cover as a better guide to edaphic conditions, water supplies, the health aspect of different districts to man and his stock and also present land usage. Such an objective survey needs to be followed up by the assessment of agricultural potentialities, based on the present knowledge of experienced local officers, and the slow acquisition of further data by observation and experimentation. Early Land-Use Maps must be largely subjective in character, and will have to be modified with increasing knowledge, and also changes in social and economic conditions. Whatever the present limitations, there is need to have some planned land utilisation, more especially in developing many African Reserves. The co-operative work to date with Territorial Officers has mainly taken the form of assisting them to recognise the main soil types in their respective districts, and the starting of the mapping of these listed soil types. Short reports have been submitted giving a descriptive account of the main soil types which Field Officers can readily recognise. These cover the Trans Nzoia, Uasin Gishu, Nakuru, Kericho and the Machakos districts.

The Study of Fertiliser Response in Relation to Soil Types

The practical application of soil survey to better land utilisation is illustrated by the study of fertiliser responses in terms of soil types, thus enhancing the value of experimental data, and making for sounder advisory work.

The very large amount of data on fertiliser responses made available by the statistical experiments of the Highland Fertiliser Scheme carried out over three years, and also a mass of analytical data for the same soils, offered great scope for correlating responses in terms of soil types. In February, the soil conditions at about 80 such experimental sites with wheat and maize were broken down and classified into soil types. So as to avoid too few sets of resultant experimental data for later statistical analyses in terms of the responses obtained with different soils, it was considered necessary to allow for a fairly wide degree of variation for the soil types classified. This system had the incidental advantage that with the resultant lesser number of described and named soils, each covering a wider range of conditions, farmers are able better to identify their own particular soils in advisory bulletins.

Seventy-five out of eighty experimental sites visited were classified into nine soil types at about the Soil Association level, with allowances for variants. At the remaining five sites the conditions had to be classified as atypical, and hence omitted from the soil type/fertiliser response correlations.

An analysis of the relationships between soil types and phosphate responses made by the Statistical Section shewed that, in spite of temporary fertility differences within the same soil types, the variations *within* each of the seven classified soils under wheat, was much smaller than the variation *between* soil types. With the knowledge of the distribution of the seven sets of soil conditions each with different calculated mean optimum phosphate requirements, it is possible to offer sounder advice to wheat growers. In the case of maize grown on less leached soils with a lower phosphate requirement, the differences between the optimum dressings for different soil types was small.

A classification of the soils at 36 sites of the African Fertiliser Scheme (1951), scattered over some thousand square miles in North Nyanza and in the Eastern Province of Uganda, gave ten main soil types, but only for six of these were there sufficient experimental data for useful correlations. It was shewn that all fifteen experimental sites classified under two main soil types, characterised by leached, highly coloured soils occurring on old land surfaces, gave good to very good responses to phosphate, but little response to sulphate of ammonia. On the other hand the more pallid, less mature soils shewed a much smaller response to phosphate, but a higher response to nitrogen. Intermediate soil types gave intermediate responses.

Land-Use Surveys have been carried out in close co-operation with the Soil Chemist of the Kenya Department of Agriculture. A paper on "Fertiliser Responses in Relation to Soil Types" and another

on "The History of Artificial Fertilisers in the European Highlands", with special reference to Sodaphosphate, have been prepared.

Co-operative Work with The Overseas Food Corporation

The Director and the Chairman, O.F.C., made arrangements whereby Soil Survey and related soil investigations undertaken by Mr. Brian Anderson of the Experimental Department, were to be co-ordinated with the Soil Survey Section of E.A.A.F.R.O. Following visits to Kongwa and Nachingwea to study the work being carried out and the scope of future investigations, it was agreed that Mr. Anderson be transferred to Nachingwea where there was a much greater need for soil survey as a basis for a scientific approach to planned development.

Special attention was to be given to assessing the relative suitability of the already cleared but, as yet, not utilised more sandy soils with a higher base saturation found on the slopes. In this region, with an advanced stage of peneplanation and a general sequence of soil conditions occurring down the slopes, soil survey would largely take the form of studying the classified component soil types. There would be the need to pay special attention to soil drainage and ease of water disposal and the ease of soil conservation measures and mechanical cultivation, besides cropping capacities. This would involve observations on any land of a known classification where present cropping had accidently extended on to the slopes of the ridges, and also some set field experimentation.

By the end of the year Mr. Anderson had completed a detailed soil survey on a scale of 1:10,000 of some 5,000 acres situated eight to eleven miles to the west of Nachingwea, including the site of the Experimental Farm, and also further survey in the Namanga region. This work is especially interesting in that this detailed survey shewed the extent to which catenary mapping is applicable in this region. Mr. Anderson's Annual Report appears elsewhere in this publication.

Statistics

P. Robinson

A substantial portion of my home leave was devoted to work at Rothamsted Experimental Station, during which time it was possible to deal with the more urgent sectional problems and data on the manuring of sugar cane were worked up. It was found that phosphate and potash had no effect on the percentage sugar, and that nitrogen tended to reduce percentage slightly.

Suggestions were circulated to the Departments of Agriculture in the four East African territories on the layout of Cassava experiments. In view of the large differences in variation associated with the large differences in yield at different lifting dates, it was felt that variety trials should be restricted to one date of lifting only; the date to conform to normal practice in each area. In certain cases it may be profitable to run two separate experiments; one to be lifted after a short period, and the other to be lifted after a longer period. This

will then divide the varieties roughly into early and late maturing types.

Methods of the botanical analysis of pasture were examined, and it was found that many species followed the negative binomial distribution. The recorded numbers of individuals of certain species of creeping-type grasses did not follow this distribution; this is probably because of the great difficulty of separating out individuals in such cases, and not because of a different type of distribution.

Maps of the reliability of annual rainfall in East Africa have been completed and it is hoped that they will be published next year. Data from about 1,200 stations were used in compiling these maps, which have already proved useful to ecologists and agriculturists. It has been found, for example, that certain ticks are confined to those regions where annual rainfall of 30 inches or more can frequently be expected. Existing maps giving average annual rainfall show no such agreement.

The technique of sampling pyrethrum flowers in bags and in bales is under investigation. Sampling the bale by means of cores has given consistent results, and the use of a probe for sampling the bag appears to be promising. The mechanical sampling of bags has yet to be examined.

Assistance has been given in designing experiments and analysing results for the Departments of Agriculture of Kenya, Uganda and Tanganyika. These include experiments on wheat in the Southern Highlands of Tanganyika, variety trials at Njoro, sisal experiments at Thika, and coffee and groundnut experiments in Uganda. Designs for pruning experiments for the Kenya Forestry Department were suggested, and the results to date analysed. Data from locust populations have been examined, and it is hoped that, by taking various measurements, the origin of migratory swarms may be determined. Assistance has in addition been given to various sections of E.A.A.F.R.O.

Joint Division of Animal Industry

STAFF

M. H. French ..... *Head of Division*
D. W. Duthie ..... *Biochemist*
H. P. Ledger ..... *Farm Manager*
I. B. Pereira ..... *Scientific Assistant*

The breeding, feeding and management of farm livestock, so that they may be economic producers of food, work or other commodities of value to man, cannot be efficiently studied in isolation from their practical relationships with crop Husbandry and Veterinary science. Consequently this Division has been established as a joint responsibility of E.A.A.F.R.O. and E.A.V.R.O. It will attempt the elaboration

and simplification of techniques, for the benefit of workers in other East African Experimental Stations, and will study specific problems concerned with the nutrition, metabolism, physiology and genetics of livestock production. In conformity with the nature of the problems and the wishes of the East African Territories, the specialist officers will work in the areas to which their problems apply or at Muguga, where 800 acres of wattle-covered land is being developed to provide the practical facilities and the farm background for their studies.

As reported by the Farm Manager last year, the work of clearing and equipping the farm and of constructing a limited number of farm buildings commenced in 1951. A Scientific Assistant was appointed in April to assist the farm manager, the Head of the Division arrived in October and the Biochemist took up his duties in November.

Whilst on leave and prior to taking up his duties, the Head of the Division attended the VIth International Congress of Animal Husbandry in Copenhagen and visited a number of Research Stations in Denmark and the United Kingdom. He has also visited, through the courtesy of the respective Territorial Directors, the Animal Health Station, Entebbe, the Empire Cotton Growing Corporation's Research Station, Namulonge, the Agricultural Experiment Stations at Serere, Kitale and Ol Joro Orok, the Kenya Grassland Station at Kitale and the Stock Farm at Engare Nairobi.

Fluorosis

D. W. Duthie

A start has been made on a study of fluorosis in cattle and sheep, a problem which would appear to be of considerable importance in certain areas of Kenya and Tanganyika. In Kenya, borehole waters in areas overlying strata of more recent volcanic origin tend to have higher contents of fluorine, whereas, in surface waters in these areas, the fluorine content is usually below toxic levels: on the other hand, in areas such as those around Mount Meru in the Arusha District of Tanganyika, surface waters are known to possess high levels of fluorine.

Since excess of fluorine may not only cause direct toxicity but may also contribute to or mask other nutritional disturbances, information will be collected on fluorine contents of farm-water supplies where clinical symptoms of fluorosis occur, or where sub-clinical disturbances are suspected. Attempts will also be made to devise a practical method whereby the fluorine content of drinking waters for farm livestock may be reduced below the toxic levels.

Farm Developments at Muguga South

H. P. Ledger

Clearing.—During the year 250 acres of regenerated wattle plantations and 175 acres of bush land were cleared. Of the area

cleared, 202 acres were stumped and cultivated but the remaining 223 acres were left for natural grass regeneration, in order to provide immediate rough grazing and to reduce the costs of stumping, by allowing all but the larger stumps to rot.

The cost of clearing, but not stumping, averaged Shs. 20/57 per acre, with wages at Shs. 45/- per month, but the final cost of stumping land, which had been cleared and allowed to regenerate to grass, depends on the number of recalcitrant stumps which have ultimately to be removed. The economics of such a system of land development depends, in fact, on whether the cash saving involved is greater than the difference between the value of the grazings obtained and the estimated value of the crops, that could have been grown, or the improved pastures, that could have been established, on the same piece of land if it had been stumped at the time of the original clearing. In considering such a problem it must also be born in mind that clearing, but not stumping, immediately entails hand slashing of annual weeds and tree seedlings until the grass is established as it is not possible to use a mower because of the stumps.

As far as Muguga South is concerned it would appear that where "Igoka" (*Cynodon dactylon*) is present it may be a paying proposition to leave stumping until later. Where however, there is no "Igoka" and the natural herbage consists of annual weeds and couch grass, it would probably be better to stump at the time of clearing in order to prevent the undesirable spreading of these grasses.

Fencing.—The perimeter fence around the whole Muguga South Estate was completed early in 1952 and the fencing of the main subdivisions during the year immediately followed the clearing of the land.

Building.—Buildings completed by the Maintenance Superintendent for the Animal Industry Division during 1952, consisted of the Metabolism Laboratory, the frame and roof of a six-bay Dutch barn, a block of six pigsties, a unit of ten loose boxes, a house containing eighteen calf pens, twelve experimental silos, a deep-litter house, a cattle dip, the plinth for a dairy and milking parlour, fourteen chicken houses and numerous items of poultry equipment including trap nests, fattening pens, food troughs, etc.

In addition, a water main was laid to the site of the farm buildings with a take-off to supply the cattle dip.

Stocking.—The underlying principle of livestock experimentation on the station is the study of the efficiency of animals in converting animal feedings stuffs into products of use to man. Cattle are, of course, the most important class of livestock in East Africa, but it has not yet been possible to initiate experiments with them because sufficient grazing has not been established and because of the more important need to bring tick infestation under control, by the regular dipping of immune stock. We are greatly indebted to the Director of Veterinary Services, Kenya, who has placed cattle at our disposal for this latter purpose.

In the meantime, the opportunity has been taken of collecting data on less expensive and quicker maturing small livestock, which will be of value *per se* and for testing out techniques which may later be applied to the more expensive, slower maturing, larger domestic animals.

Details of stock received are given below:

Poultry.—Day-old birds were imported from the United Kingdom, and it is hoped to obtain information on the extent to which the change in environment may cause deterioration in efficiency in the original or the succeeding generations when feeding and management conditions are maintained as constant as possible.

Records kept include individual weight records of all birds from date of hatching to laying, individual egg records (weight, fertility and hatchability), records of food consumptions and carcase analyses showing the proportions of meat, bone, and offal, etc. A study of the economics of different methods of caponisation has also been started.

Breeds of Poultry imported.—North Holland Blue, Welsummer, Brown Leghorn, Legbar, Gold and Silver Cambars, Aylesbury Ducks and Roman Geese. We are indebted to Mr. Pease and the Cambridge University Institute of Poultry Genetics for presenting the farm with the Gold and Silver Cambars.

Indigenous flock of Masai Sheep.—Thanks to assistance given by the Kenya Veterinary Department, a small flock of Masai sheep has been established.

Pigs — Large White.—Three pedigree Large White gilts, one in pig, and an unrelated boar were purchased from the Tanganyika Veterinary Department stock farm at Mpwapwa.

Grass and Fodder Crop.—Grass and fodder crop reference plots have been established with the triple object of providing for our own use and for any other research station that may require them —

(a) living specimens for reference purposes;

(b) planting material;

(c) records such as rate of growth, stalk:stem ratios, drought resistance, seed production and seed viability.

It should be noted here that the majority of the grasses have merely been established in 1952 and that recording, on the lines given in (c), is only just beginning.

We are greatly indebted to the Kenya Pasture Research team of Kitale and Kabete for providing much of the planting material.

Altogether 90 types of grass, 14 legumes and 10 fodder crops were grown during 1952 and it will be seen that the grasses cover a range

from the small Cynodons to the large Pennesetums (Elephant grass) and include known economic grazing grasses as well as annuals, 'lawn' and 'weed' grasses. We should be glad to exchange planting materials or seeds of grasses and promising fodder crops with any station interested, bearing in mind that the altitude here is 6,700 ft. with an average rainfall of 35 inches.

Silage.—Seven types of silage have been made either in pits, experimental silos or in a single tower silo and their examination awaits the arrival of the nutritional chemist. Types of silage made include oats, oats and vetch, maize, maize and lupin, buckwheat, sunflower and Kavirondo sorghum.

Observations on Grazing Grasses Sown in 1952.—Of the grasses sown in 1952, *Chloris gayana, Bromus marginatus, Melinus minutiflora, Lolium perenne* and *L. italicum* were the only ones to provide grazing in 1952. *Bromus* was the first to reach the grazing stage and *Chloris* was the last. In persistence and the total bulk of fodder production, however, *Chloris* proved superior to *Melinis*, which in turn surpassed *Bromus*, and the exotic *Lolium* species were the least successful. The exotics on the other hand were the most palatable, followed by *Bromus* and *Chloris*, and *Melinis* was much less liked. Whereas *Bromus* and *Melinis* produced seed freely the imported grasses set no seed.

Notes on crops grown during 1952

Lampton Oats.—Lampton oats, grown for hay and silage, did well but, where grown for grain, failed to fill and only bushelled out at the very poor figure of 25 lbs. per bushel.

Lampton Oats and Hairy Vetch.—This mixture was grown for silage with the Vetch sown ten days earlier than the oats. This was not a long enough interval and the oats crowded out the Vetch. In 1953, the planting of the Vetch will precede that of the oats by an interval of up to three weeks.

Beans, Canadian-Wonder.—This year's sowing, at the rate of one bag to five acres in 21-inch rows, proved to be about right for this crop and was a great improvement on last year's closer drilling. Even so, 28-inch rows would probably be a further improvement, because the 21-inch rows are difficult to clean mechanically in view of the small margin for error.

Unfortunately drought at the end of 1952 ruined any hopes of a greater return than the amount of seed drilled.

Barley.—"Research" proved a very good yielder this year and bushelled out at 53 lbs. Owing to ravages by birds no accurate measurement of yield could be taken.

Edible Lupin.—Edible blue lupin proved as reliable a crop in this year of light rainfall as it did in last year's heavy rain season.

Kale.—Both Marrowstem and Thousand-headed Kale have proved themselves to be vastly superior to any other crop so far tried, for providing ample green fodder well into the dry season. It is probable that Thousand-headed Kale will prove the better of the two. Its stems do not get very woody, and therefore do not have to be split by hand as is the case with the Marrowstem variety. It will also provide fresh fodder after even a little rain.

ATTACHED C.D. & W. SCHEMES

Termite Research

STAFF

W. V. Harris ..... *Officer-in-Charge*
P. B. Kemp ..... *Research Officer*
W. A. Sands ..... *Research Officer*

Miss Kemp resigned at the end of September. Mr. Harris left East Africa in October on leave pending transfer to the Commonwealth Institute of Entomology, London, where he will continue as Officer-in-Charge, Termite Research Unit. Two entomologists have been recruited for training and they will join the Unit in East Africa in 1953.

Biology

The ecological survey of the termites of north-eastern Tanganyika has been concluded, and Miss Kemp has prepared a detailed account of her work. Publication, however, must await specific identification of a number of the termites collected, as facilities do not exist in East Africa for this. At present, 104 species are recognised in this collection, though further work may reduce this number slightly. The area under review was divided into eight zones, in one of which—the coastal plain—the number of species recorded was 76, while in the montane cedar forest zone the number of species found was 4. Some species have proved to be locally abundant and of use in delimiting the particular zone in which they occur. Other species occur regularly in two or more zones. This detailed study of the termite fauna of a small area embracing a wide range of climatic conditions should prove of value when the geographical distribution of the termites of Africa south of the Sahara is under consideration.

The feeding habits of the higher termites are being studied by Mr. Sands. Progress has been made in the design of laboratory nests to permit of transplanting portions of colonies for observation. The non-fungus-growing genera *Microcerotermes* and *Cubitermes* have so far proved more amenable than the fungus-growing *Odontotermes*, and their foraging habits are being studied. As far as possible the foraging habits of *Odontotermes* are being observed in the field. Use was made of dyed and pigmented material to determine the rate of movement of food through the various parts of the alimentary canal, and the amount of food ingested by the foraging worker. Powdered animal charcoal gave the best results. The role of the fungus comb in the economy of *Odontotermes* is being studied and experiments so far carried out indicate that the presence of fungus comb in the diets of worker termites confined in the laboratory increases significantly their survival rate. Anatomical differences in the alimentary canal between the fungus-growing Macrotermitinae and the non-fungus-growing Amitermitinae have been noted.

Experimental nests for the foundation of new colonies with alate reproductives have not been very successful except in the case of *Anoplotermes*.

Systematics

Work has continued on the collection. Special attention was given to the genus *Anoplotermes* owing to the discovery of numerous colonies containing alates in various localities immediately prior to the rains, and to the finding of a number of migrating colonies with queens. Absence of a soldier caste and generally subterranean habits with a minimum of nest organisation have contributed to the lack of knowledge of this genus in East Africa, but there is no doubt that it is one of the commoner genera and numerous enough under most conditions to play a significant part in the biology of the upper layers of the soil.

Intensive collecting has been carried out in selected localities in Kenya and Uganda, particularly in the drier areas, in order to complete our distribution records.

Ruanda-Urundi

A collecting trip was made in northern Ruanda-Urundi during June. The assistance afforded by the Belgian Authorities is gratefully acknowledged. Over 20 species of termites belonging to 12 genera were obtained, a number of these being new to the East African list.

St. Helena and Ascension

Opportunity was taken during the sea voyage to England to pay a brief visit to St. Helena. With the kind of co-operation of Mr. N. Humphries, Agricultural Officer, it was possible to see something of the problem which has arisen from the introduction of a dry-wood termite, *Cryptotermes brevis*, from the Americas, and the subterranean-nesting *Heterotermes platycephalus* from Australia. Both termites attack the timber-work of buildings, but *H. platycephalus* also attacks apparently healthy trees, including cupressus and wattle.

It is not possible to land at Ascension Island but specimens of *Cryptotermes sp.* damaging the timber of buildings there were obtained through the assistance of Mr. F. B. Stephens, Resident Magistrate, to whom we are greatly indebted.

Somaliland and Arabia

Officers of Desert Locust Control have continued their valuable assistance in providing specimens from some of the less accessable parts of Somaliland and Southern Arabia.

Economic

The native dry-wood termite, *Cryptotermes havilandi*, has been found in a number of the older buildings in Mombasa. There is little doubt that this insect will be recognised as a serious pest of buildings in the East African coastal zone as time goes on. There is, at present, a tendency to ascribe the damage to dry rot. With the assistance of Dr. Coaton and officers of the South African Division of Entomology, it was possible to see something of the damage which is being done in Natal by the introduced *Cryptotermes brevis* and at Simons Town by *Coptotermes formosanus*, and the control measures adopted.

It has not been possible to organise further field trials of termite proofing materials, but laboratory methods of testing are being investigated.

Identifications have been made and control methods suggested to Departments and individuals in all the East African territories, in Nyasaland and the Rhodesias.

Ecological Training Scheme

STAFF

C. G. Trapnell ..... *Officer-in-Charge*
I. Langdale Brown ..... *Research Student*
E. C. Trump ..... *Research Student*
N. R. Brockington ..... *Probationer, Northern Rhodesia*

Preliminary reconnaissance tours by the Officer-in-Charge were continued during the period January to March inclusive. These tours were made in company with Messrs. G. H. Gethin Jones and R. M. Scott with a view to joint study of soil and vegetation types in the southern Kenya region.

They comprised (1) country on the circuit Nairobi-Arusha-Voi-Nairobi, (2) the experimental sites of the Highlands Fertiliser Scheme and (3) the Machakos area and adjoining country towards Kitui. On the first tour a visit was made to the Soil Conservation section at Tengeru (Arusha) for the purpose of consulting (the late) Mr. D. Thornton, Chief Soil Conservation Officer, Tanganyika, on training methods employed by him at Tengeru and on possible co-operation in field work. A considerable amount of botanical collecting was carried out, with particular reference to the genus *Acacia*. The second and third tours were made jointly with members of the Kenya Department of Agriculture. They included visits to several Agricultural Stations in the Highlands region and discussion with Mr. V. R. S. Beckley at Machakos on ecological questions which he is studying in that district.

At the end of March I went on overseas leave for four months. In the course of leave, visits were made to Oxford and Kew, in order to discuss the final courses of Research Students in training for the Scheme in England, and I also attended at the selection at the Colonial Office of candidates for the following year's course. Post-graduate training under the Scheme in England is at present being carried out principally at the Departments of Agriculture and Forestry, Oxford, with supplementary botanical work at the Kew Herbarium.

The first two Research Students under the Scheme, Messrs. I. Langdale Brown and E. C. Trump, arrived at Muguga at the end of September, having completed their year's post-graduate training at Oxford, and were accompanied by Mr. N. R. Brockington, Colonial Agricultural Probationer from Cambridge, who is training for the post of Ecologist in Northern Rhodesia.

In the meantime, following my return from leave, arrangements were put in hand for the initial survey of the 1952-53 course, namely, a reconnaissance vegetation survey of the West Uganda Rail Extension zone between Mityana and Lake Edward. This survey was undertaken at the request of the Director of Agriculture, Uganda, with a

view to preparing the ground for future land-use studies in this region. Preliminary studies of literature bearing on the climate and physiography of the Rail Extension region were made at Muguga in October and the field work was carried out in November and December.

The Uganda tour included a brief preliminary field study in country between Eldoret, Kakamega and Kitale, with a visit to the Grassland Research Station at Kitale, visits to Entebbe Botanic Gardens and Mpanga Forest under the guidance of Mr. H. C. Dawkins, Forest Ecologist, and preliminary work on the selection of air photo cover at Entebbe. The working area of the survey comprised the country between the Mityana—Fort Portal and Masaka—Mbarara roads, limited to the west by the Mbarara-Ibanda-Fort Portal road, and occupied approximately 7,000 square miles. This region is characterised by a much dissected topography and an abrupt series of climatic changes, and the main purpose of the survey was to classify the vegetation in relation to these factors and to the effects of human occupation, and to prepare an outline vegetation map. The area was covered by a skeleton of traverses, employing car mileometer records along all available routes, with a view to subsequent interpolation from air photographs. The vegetation of a great proportion of the country was found to have been much modified by fire, grazing and human occupation, and the changes induced by these factors required simultaneous study. Particularly noteworthy were widespread indications of deterioration of former grazing areas, involving large-scale encroachments of tussock grass (*Cymbopogon afronardus*) and of short *Acacia* scrub (*A. seyal* var. *multijuga*). At the same time much light was obtained on the main pattern of climatic types of vegetation through the region, which should facilitate its zoning for future development purposes. On return to Entebbe a final selection of air cover was made, and the large number of photographs needed to complete the mapping work were kindly loaned by the Survey Department, together with further photographs from the Forestry and Public Works Departments. Visits to the Agricultural Research Station at Kawanda were made on both the forward and return journeys, and the survey benefited greatly from the help which it received from members of these Departments and from District Officers in the areas concerned. Work on the air cover will be carried out in the New Year.

REPORTS BY O.F.C. OFFICERS

On the reorganisation of the Scientific Department of the Corporation in 1951, several specialist officers were attached to E.A.A.F.R.O. as their work is allied to that being carried out at Muguga. Mr. Anderson is chiefly concerned with elucidating the soil types in the Nachingwea Area, having completed this type of work for Kongwa. Soil work at Kongwa is now restricted to a study by Mr. Wood, with the assistance of the E.A.A.F.R.O. Soil Physics Laboratory, of the soil-moisture and soil-structure changes arising from experimental methods of soil-moisture conservation in this marginal area. The biggest single factor limiting the successful

production of groundnuts by the Corporation in Nachingwea and Urambo Areas, is the virus disease "Rosette"; Dr. Evans has concentrated mainly upon a detailed study of the aphis vector.

Rosette Disease of Groundnuts

A. C. Evans

Work has been devoted mainly to a study of the field biology of the aphid vector (*Aphis craccivora* Koch) of this disease.

Nineteen species of plants in the bush have been found bearing colonies of the aphis. *Dolichos malasanus* Bak. and *Indigofera rhynchocarpa* Welw. ex Bak. flower in November and early December independently of the onset of the rains and carry flourishing colonies. *Vigna reticulata* Hook f. and *V. triloba* Walp. germinate with the first rains and prove very suitable hosts throughout the rainy season and well into the dry season. Infested plants of these latter species have been found throughout the dry season in suitably moist places, such as valley bottoms. Regeneration of a species of *Millettia* or *Lonchocarpus* is also a suitable host during the dry season. The other hosts found are of secondary importance. Thus the vector is independent of groundnuts for its survival during the whole of the year.

Several species of Syrphids and Coccinellids play an important role in killing off numbers of aphids, but their effect is only to reduce slightly the rate of spread of the disease on Natal Common, the principal variety grown by the Corporation. In a 25-variety trial in 1951 it appeared that two varieties, Mwitunde Urambo and Mwitunde Ukiriguru (really mixed strains selected out of Asirya Mwitunde grown in the Tabora district) showed evidence of being less rosetted than the remaining varieties. These two varieties were incorporated in the 1952 trial and detailed observations made. The initial level of aphid infestation on the two "resistant" varieties was equal to that on four susceptible varieties, as was the incidence of primary rosette infections. One month later the incidence of the disease was higher on most of the other varieties and patches of secondary spread were appearing. These continued to increase in number until 15 varieties had all 6 plots affected by secondary spread, 7 had 5 plots affected, 1 had 4 plots affected and the 12 Mwitunde plots had only 1 plot affected. This "lesser affliction" of Mwitunde by rosette was strikingly shown by two small adjacent panels, each 2 acres in area, planted up for single-line selections. One panel was occupied by the two Mwitunde, the other by Matevere and Kanyoma, all spaced at two feet in 34-in. rows, ideal conditions for the spread of the disease. By March, sheets of secondary spread were present on the two susceptible varieties and only individual infected plants could be found amongst the Mwitunde.

A number of Mwitunde seeds were substituted for Natal Common seeds at wide intervals immediately after a panel was planted with this variety. The Mwitunde plants and some Natal Common were infested with two apterous adult aphides taken from infected plants. Fifteen days after infestation the number of Natal Common plants

carrying colonies was significantly higher than that of the Mwitunde, and the resultant secondary spread from infested plants onto adjacent Natal Common was 6 times greater for Natal Common than for Mwitunde.

Thus the evidence is strong that Mwitunde does not become so heavily infected with rosette disease as do Natal Common and other varieties in the Nachingwea area. The simplest hypothesis that explains the above results is that the rate of reproduction of the aphis on Mwitunde is lower than on other varieties and that the local population of predators is sufficiently high to exterminate a large proportion of the initial colonies and to prevent many of the remainder becoming so large that overcrowding causes movement of infected aphides onto neighbouring plants. Preliminary experiment suggests that the rate of reproduction is several times lower on Mwitunde than on Natal Common. Other hypotheses are also being tested. Mwitunde differs strikingly from the other 97 varieties in the local collection in its symptomatic reaction to rosette. The first symptoms occur about 6 days earlier on Mwitunde and the second and third leaves become flaccid and brown and tend to drop off. Later expanded leaves show widely varying degrees of chlorosis. The degree of internodal shortening also varies considerably from plant to plant even when infected at the same age. Thus it appears that the genetic constitution of Mwitunde in relation to rosette disease is very different from that of other varieties, and the variety, or rather mixture of strains, known as Mwitunde may prove a valuable source from which might be isolated stains of agricultural value, bearing a high resistance to aphides and perhaps other characteristics of value in combating the ravages of the disease.

Field spraying or dusting is expensive and is not likely to prove economic. It has been found that the systemic insecticide Schradan can be absorbed by the seed in sufficient quantity to prevent reproduction of aphides during the first 3-4 weeks of growth, and probably at a lower rate for a short time longer. Thus with an efficient predator population it might well be possible to prevent or reduce considerably the extent of secondary spread, even in a variety like Natal Common.

Both methods of control outlined above are essentially dependant on utilising the local population of predators. The local vegetation is singularly free of aphides, only three species have been found in any numbers, *A. craccivora* and two unidentified species living on the perennial *Vernonia glabra* (Steetz) Vatke (Compositae). It should be possible to maintain a high level of predators in the region by encouraging the growth of this species in field verges and contour banks, so that partnership between "resistant" variety or insecticide, on the one side, and predators on the other is not broken. Neither of these aphid species have been found on or bred on groundnuts.

Soil Survey and Management

B. Anderson

In the early months of the year, during the wet season, an area around the Experimental Farm, 10 miles west of Nachingwea, was

surveyed. A soil map to the scale of 1 in 10,000 and covering about 8 square miles was produced. Work was then started in the Namanga area, 2 miles north of Nachingwea, where the topography is somewhat different. This was continued up to the end of May, when the ground had become too hard for the soil auger and surveying was discontinued.

In the Nachingwea district, lateral transport of soil material has played a large part in the formation of existing soils. The successive horizons of the soil profile may therefore vary greatly in texture, and horizons of impeded drainage often occur. For a detailed survey it is essential to examine the subsoil at frequent intervals and this means in practise that the ground must be moist enough for a soil auger to penetrate. In the drier Kongwa area, where a survey was carried out in 1951, it proved to be possible to map the soils during the dry season. Here there is little differentiation of the texture with depth and all that one needs to know of the subsoil can usually be discovered by inspection of material brought to the surface by ants (true ants). This is easiest in the dry season, after the vegetation has been burnt off.

The soil laboratory in Nachingwea was ready for occupation by June and the remainder of the dry season was occupied with the analysis of soil profiles from pits in the two areas surveyed. We are grateful to Dr. H. F. Birch of E.A.A.F.R.O. for assistance in analysing a number of samples.

The higher-lying soil series so far recognised fall into two groups. In the first the soils are usually deep and are loams or sandy loams; in the second group the soils are shallower and sandier, the difference possibly being due to different parent rock. The valley soils derived from the first group do not seem to differ appreciably from those derived from the second. It is therefore possibly to classify the soils in the following way:—

Deep soils	*Shallow soils*
Nachingwea series	Namatula series
Nagaga series	Mitumbati sand
Nailala sand	
Nangoi sand	
Naipingo series	
"Vegetable Farm" clay	
Nkumba clay.	

This gives the soils in their order of occurrence down the slope. There are, therefore, two catenas. The first, the Nachingwea catena, starts with the Nachingwea series at the top of the slope and ends with the Nkumba clay in the valley bottom. The second, the Namatula catena, starts with the Namatula series and also ends with the Nkumba clay. In any one traverse across a valley it is, however, the exception rather than the rule for all the members of the catena to be present. In the minor valleys the lowest member of the catena is the Naipingo series since the two clays do not form in such a situation. In the major valleys, where the flood water slows

down, either the "vegetable farm" or the "Nkumba" clays follow the Naipingo series; possibly these two clays are alternatives for the lowest position, rather than successive members of the sequence, since they rarely occur together. Similarly the Nangoi sand, which may consist of 95% of coarse and fine sands with only very small amounts of silt and clay, only occurs under particular topographical conditions. All the soils below the Nagaga and Namatula series arise from the re-sorting of material washed down the slope from the higher-lying series. It rarely happens that the degree of slope, volume of water, etc., are just right for the complete separation of sand that occurs in the Nangoi series.

All the soils in the Nachingwea area are derived from Basement Complex gneisses. It seems probable that the soils of the Nachingwea catena are derived from gneisses with a relatively high content of hornblende or other iron-containing mineral, while the sandier and paler soils of the Namatula catena are derived from the more acid gneisses.

The red sandy loams of the Nachingwea series and the Nagaga sandy loams, with a more orange subsoil, are probably the most generally useful soils in the district; but owing to their position at the top of the slope they suffer most from droughts. The crops and natural vegetation of soils of the Nailala series suffered less during the dry spell which occurred in late January and early February, 1952. Some of the higher-lying soils of the Nailala series were brought under cultivation, particularly in the early clearings, and have grown good crops. During the year a small area of a low-lying phase of this series was cleared for experiments with crops having a high moisture requirement, e.g., jute.

The main difficulty with the Nailala series is soil conservation in the presence of termite mounds, which are often numerous on this soil. Rainwater shed from the mounds collects in the low-lying areas between mounds and floods furrows and terraces, causing breaks during heavy storms. Early in the year the O.F.C. flattened several mounds by bull-dozer but the cost was high and the resulting field, a patchwork of clays and sands, almost impossible to work. Also the clay from the cores of the mounds, with a pH over 8, is too alkaline for the growth of some crops, e.g., groundnuts.

The soils of the Namatula, or "shallow", catena are normally deep enough for cultivation, although local rock outcrops sometimes interfere. They tend to suffer from the defects of the Nailala series, i.e., ease of erosion and presence of termite mounds, but they appear to have been selected in the past for African villages—mango and cashew-nut trees are found on these soils—and their potentialities require investigation.

The Nangoi sands are probably too infertile and too erodible to be of agricultural use. The Naipingo and lower soils suffer from waterlogging and can probably best be used for grassland. In many of these soils the water-table remains within reach of deep-rooting plants for much of the dry season. The Nkumba clays, lying in level bottomlands, might be suitable for paddy rice and a small area is to be tried in the coming season (1953).

A detailed account of these soils will be published elsewhere, when analysis of the profiles has been completed.

The difficulties caused by termite mounds in sandy soils have already been mentioned. With a view to improving their water absorption a trial was made of a proprietary synthetic soil conditioner. This material, at a concentration of 1 part conditioner to 650 parts of soil, remarkably increased the permeability to water of termite mound material. Similar improvements in structure and permeability were obtained for a red sandy clay (Nachingwea series) and a grey sand (Nailala series). So far, only enough material has been obtainable for pot-scale trials.

Following complaints by the farmers that land was becoming "exhausted" after three or four seasons of cropping, some work was done on water-stable crumb structure, chiefly with soils of the Nachingwea series. Comparison of fields cropped for one, two, three and four years with adjacent uncleared areas showed a marked and progressive reduction in water-stable crumbs. This results in "capping" when the soils dry after heavy rain, with a consequent low penetration of subsequent rain and possibly damage to emerging seedlings. It is possible that nitrification in the soil may be affected also, but there is no evidence of exhaustion of calcium, phosphate or potash. The Experimental Farm at Nachingwea is to lay down grass leys and green manure plots for investigations into the improvement of soil structure and the effect on subsequent crops.

Some measurements of soil temperatures were made at Nachingwea (altitude 1,500 feet). Two recording thermometers, their bulbs buried at depths of two inches and twelve inches respectively, were used, and measurements were made for a period of seven consecutive days, sometimes more, in each month. The soil, which was a red sandy loam of the Nachingwea series, was smoothed over after the burial of the thermometer bulbs and was kept free from weeds. The highest temperatures were reached in December, with a mean maximum (for 17 days) at 2-inch depth of 47.0° C. (116.5° F.). The absolute maximum was 49.8 C. (121.6° F.) at 2 inches on 23rd December. The monthly means of maxima and minima at both depths are given in the following Table:—

	2-inch depth		12-inch depth	
Month	Minimum °C	Maximum °C	Minimum °C	Maximum °C
February	23.7	39.3	27.5	30.1
March	25.5	42.7	29.9	33.4
April	23.8	37.6	27.7	30.4
May	22.7	33.8	25.6	27.5
June	21.2	36.9	26.6	29.6
July	18.7	34.7	24.7	27.6
August	20.8	36.2	26.0	28.6
September	22.1	40 5	27.8	31.0
October	23.2	41.3	28.6	32.2
November	24.6	42.9	29.9	33.3
December	27.4	47.0	32.4	36.4
January	24.7	38.7	29.1	32.2

The temperatures during the wet season (December to May) are influenced by the rainfall. The high temperatures in March and the low temperatures in May were due to the recording period coinciding in March with a dry spell and in May with a wet one. Similarly the figures for November and December are influenced by a November rainfall of 4.23 inches and a December rainfall of 0.27, the latter being abnormally low.

Similar measurements were made in Kongwa (altitude 3,400 feet) in November and December 1951 and January 1952. The November rainfall was 0.67 inches but December had 6.64 inches and January 5.17 inches of rain. The monthly means given in the Table are for the whole month. The highest temperature recorded was 47.2° C. (117.0° F.) on 3rd December. The results were:—

	2-inch depth		12-inch depth	
	Minimum	Maximum	Minimum	Maximum
Month	°C	°C	°C	°C
November	23.3	42.2	29.2	30.2
December	22.7	39.8	28.5	29.6
January	23.3	37.3	27.5	29.2

Soil Moisture Studies at Kongwa

R. A. Wood

This project is an investigation of "dry-farming" techniques for Kongwa conditions. It is hoped that means can be found to store water in the soil during a fallow year and thereby to avoid drought-effects in the subsequent crop of groundnuts. During 1952, the first season was completed for a set of five two-year rotations. Water used by the crop, and that left in the soil at harvest, was measured under (a) maize, (b) sorghum, (c) clean-weeded bare fallow, (d) fallow left to volunteer weeds and (e) fallow sown with a short-season shallow-rooted grass. These five treatments were laid out as a 5 x 5 Latin Square, with 1/10th-acre plots. Cylindrical gypsum blocks, prepared in Dr. Pereira's laboratory in 1951, were installed during the growing season in all five treatments, in duplicate profile-sets from 6 inches to 6 feet deep. Delay in the delivery of a suitable drill-rig prevented deeper recording, but the root-ranges of all of the crops were adequately sampled. Soil-sampling for moisture content was carried out to 3 feet, and when possible to 6 feet, at intervals, in order to supplement the sypsum-block records by quantitative data. The volumetric conversions of these samplings were based on 4-inch x 3-inch cores obtained from several pits, while many surface core-samples were taken for structural observations in the different rotation treatments. More than 80 cores were studied in the E.A.A.F.R.O. Soil Physics laboratory, where determinations of pore-space distribution, volume weight and percolation rates were made, and the storage changes were calculated.

Root-washing studies were carried out on maize and sorghum during the growing season and were recorded photographically. The roots of both crops were found to a depth of nearly 6 feet, which was also the depth of penetration of the rainfall as found by auger sampling.

The growing season was a good one, with 21.92 inches of well-distributed rain. A very good maize crop (3,500 lbs. per acre) was obtained, while a good sorghum crop was lost to birds at harvest. These results were paralleled on a large scale on the Kongwa farms.

Volunteer weeds and grasses on the uncultivated fallow removed about as much water as did the heavy maize crop; both reduced the soil profile to the wilting range, while the bare fallow conserved approximately seven inches of available water in the first six feet. The attempt to protect the fallow with a short-lived grass crop, of shallow root-habit, was most successful. Teff (*Eragrostis abyssinica*) provided an excellent soil protection, while confining its roots to the top 18 inches of soil. The water conserved within the first six feet amounted to six inches under this "short grass fallow."

The pore-space available for moisture storage within the root-range is, however, rather low in this sandy loam; and the extent to which this stored water will ensure next season's crop against drought must still depend to some extent on the distribution of the coming rains.